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**How to Recombine Large Technical Systems
The Case of European Organ Transplantation**

Ingo Braun and Bernward Joerges
Wissenschaftszentrum Berlin für
Sozialforschung

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The Case of European Organ Transplantation

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How to Recombine Large Technical Systems
The Case of European Organ
Transplantation

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HOW TO RECOMBINE LARGE TECHNICAL SYSTEMS. THE CASE OF EUROPEAN ORGAN TRANSPLANTATION

Abstract

The article deals with the interrelationships of various infrastructure systems--phenomena that up to now have hardly gained research attention. The authors focus on the technical networking of different networks. Taking the example of European organ transplantation, they demonstrate in which way various transport and telecommunication systems must be linked with each other for the operation and control of organ transplantation. After a description of the special problems transplantation medicine faces in this connection, the authors try to integrate the observed networking phenomena into their theoretical concept of first and second order large technical systems. Finally, they discuss possible long-term effects on the infrastructural landscape of industrial countries that might crop up in the course of the networking of networks.

ZUR REKOMBINATION GROSSER TECHNISCHER SYSTEME. DER FALL DER EUROPÄISCHEN ORGANTRANSPLANTATION

Zusammenfassung

Der Beitrag beschäftigt sich mit den von der Forschung bislang kaum beachteten Beziehungen, die die verschiedenen Infrastruktursysteme untereinander aufweisen. Im Mittelpunkt steht dabei die technische Vernetzung von unterschiedlichen Netzwerken. Am Beispiel der europäischen Einrichtungen zur Organtransplantation wird gezeigt, wie zur Abwicklung und Kontrolle des Transplantationsgeschehens die verschiedenen Verkehrs- und Kommunikationssysteme miteinander verknüpft werden. Die Autoren beschreiben die besonderen Probleme, die sich hieraus für die Transplantationsmedizin ergeben. Anschließend versuchen sie, die beschriebenen Vernetzungsphänomene mit dem Konzept der großen technischen Systeme erster und zweiter Ordnung theoretisch abzubilden. Zum Schluß werden mögliche Konsequenzen diskutiert, die solche Vernetzungen von Netzen langfristig für die Infrastrukturlandschaft in den Industrieländern mit sich bringen könnten.

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I. CROSSING BORDERS

On a late night in April, 1993, an airplane carrying a donated liver on its way from Birmingham to Edinburgh crashed¹: Liver, pilot and co-pilot were saved from the bottom of the Firth of Forth by divers of the British Royal Navy and the precious part was duly delivered to be implanted into a 25 year old woman.

Such stories begin to suggest how organ transplantation involves the transgression of borders in many senses of the word. We will be concerned in the following with the technologies that make possible the crossing of considerable spatial and temporal borders required by organ transplantation on the scale practised at present (and presumably largely surpassed in the future). But the building up and the dynamics of European and other **trans-border organ transplant systems** (TOTS) can hardly be understood without taking into account the crossing of borders--and attendant blurring of categories--between body and machine, between gift and commodity, between individual and collective ownership, between moral duty and abomination, between death and life.

Indicative of the transborder character of organ transplantation is also that many of its public problematisations arise outside the medical sphere properly speaking, at the far end, as it were, of extended systems. Two of many examples are news about "organ tourism"² (and on the first official demarche of a surgeon to operate a commercial organ bank) or reports on "organ hunting" in Honduras³. Quite possibly, these are instances of the "urban myths" that have sprung up around organ transplantation, circling the news media around the world and being retold like latterday fairy tales. But there are more solid fringe phenomena. For instance, the organisation of transplantation enclaves in pre-war Kuwait where in a local legal vacuum, US-American surgeons, West German medical apparatus and Indian hearts, and of course a little money, combined in the production of organ transplantations which could hardly be achieved within regular health systems. At the same time, a debate is played out in the US on whether the transfer of (US) organs to countries allowing organ implantation but not organ explantation (e.g., certain Moslem countries) should not be controlled and restricted.

We render such stories at the outset, not only in order to create a sense of the extendedness of the system we are going to discuss, but also to dramatise the turn to

1 Frankfurter Allgemeine Zeitung, Nr. 80, 05.04.1993.

2 Washington Post, 19.03.83.

3 Die Tageszeitung, Berlin, 12.07.1988.

technology we are going to perform in this discussion. Focussing on the role large-scale technical systems play in setting up TOTS means to systematically decenter typical controversies and to draw attention to the non-human (that is non-bodily) action media (machineries in the widest sense of the word) on which TOTS is based. We will show that these machineries are in good part (ostensibly non-medical) large scale technologies, on which today's organ transplantation parasites. When we first presented TOTS to an audience at the *Wissenschaftszentrum Berlin*, it was not readily understood that it could be a case in point for the study of large technical systems, "organ transplantation surely being at the stage of manufacture technologically" as one discussant put it. On the contrary, we argued, organ transplantation rests (as yet uniquely within the health domain) on a particular type of large technical network.

Understanding the Growth of Large Technical Systems

This particular book on large technical system dynamics is concerned with transformation. Of course, more or less radical transformations have from the beginning been a prominent theme in large technical systems analyses (Mayntz/Hughes 1988, La Porte 1991). In a way, the need to understand large-scale and historically unprecedented transformations was at the very root of most research in the field. In the process, numerous mechanisms contributing to these transformations have been proposed or identified⁴ and it seems to us that mainly three heuristic strategies have been put to work: internalist, externalist, and co-evolutionary.

Internalist strategies assume auto-catalytic mechanisms within systems. One looks for system properties making for increases of scale and diversification of services. Thus dispositions and control over resources of dominant actors, economic pressures in load management, technological reverse salients, organisational inertia, and similar mechanisms have served as explanatory concepts for system transformation.

In contrast, **externalist strategies** highlight the functional dependence of large technical systems on their ecological and societal environments. In order to explain growth and transformation one looks here for positive feed-back mechanisms linking, for instance, the emergence of networked large-scale systems to the development of all kinds of smaller-scale technologies, both in production and consumption. Especially various non-technical environments - economic, political, scientific, cultural, and so forth - are attributed power to control large technical system growth and transformation:

4 For an overview see Braun/Joerges (1993).

Of course, most analyses combine internalist and externalist viewpoints. Seldom, however, has conceptual attention been drawn to large technical systems as an important environment of large technical systems, although historical accounts abound with examples. Let us call strategies looking for mechanisms of transformations at the level of interrelationships between functionally different large technical systems **co-evolutionary**. Several co-evolutionary growth dynamics may be identified almost a priori. In the first instance, competition between technologically different systems serving similar functions come to mind. The case of rival gas and electricity systems at the turn of the 19th century is a well-known example. On the other hand, linkages and complementarities between large technical systems serving closely related functions are familiar enough. The symbiotic growth of air traffic and telecommunication, for example, or the railroad and the telegraph, or railroads and electricity, have been variously described. Sometimes complementarity turns into full technological integration or fusion of initially functionally different large technical systems, for instance ISDN in telecom.

The recombination of heterogeneous parts of large technical systems into new systems with their own internally or externally attributed and legitimated institutional identity is another co-evolutionary variant. We present TOTS as a case in point for such multiple border crossings between several large technical systems. Recombined systems of this sort, superseding classical, in our terminology **first order large technical systems**, constitute what we shall call **second order large technical systems**. The notion of first order large technical systems refers to the familiar, (relatively) easily delimited all-purpose infrastructures such as road, railroad, energy, and telecommunication systems which have been at the centre of large technical systems research. By contrast, the notion of second order large technical systems refers to the process of networking parts of different first order systems for the purposes of specific, macro-level social domains (see also Braun 1993, Joerges 1992). We suggest that much of present-day large technical systems expansion and transformation can be interpreted as a superimposition of second order large technical systems on more or less stabilised classic infrastructural systems, and we will return to a more abstract elaboration of this concept at the end of the chapter.

Our Approach to Studying TOTS

The transborder scale of organ transplant technology requires and produces a host of locally problematic "harmonising" requirements across participating health systems. Judging from the past, a progressive and internationally uniform metrification of the

human body, a legal and technical normalisation of organ explantation, of death definition and diagnosis, and standardised forms of costing will be likely outcomes. Will the technical, legal and economic normalisation of TOTS be accompanied by a leveling of local cultural meanings and symbolisations? What changes will occur in relevant professional systems and control over health policies? What will be the role of and the repercussions for local health systems and to what extent will a technically integrated European TOTS be centralised or dispersed in terms of its politics? How will the difficult issues of unequal organ distribution and non-medical selection criteria be resolved throughout TOTS?

Such questions lurk in the background of our study. While we will provide some tentative answers to some of them, our main interest is to show to what extent the underlying processes are conditioned by the growth of a large technical system of organ transplantation. Conditioned not in the sense that this technical system imposes particular outcomes on these processes but in the sense that they owe the system their very existence. All the ethical, moral, legal, economic and professional problems associated with so-called "brain death," for instance, result from TOTS technology, and it is hard to underestimate the role of brain death technology in the development of organ transplantation: brain death was invented in TOTS as a major means to increase and speed up organ supply.⁵

Here we will concentrate on non-medical network technology, however, and describe the processes of technical extension TOTS went through. Emphasis on TOTS dynamics having to do with **technical** system change implies that we will not be able to spell out in detail non-technical (organisational, economic, legal, cultural) loops. But of course, ours is not an engineering or medical discourse. Rather, what we have tried to do was: to mark the technical moments generating non-technical issues and non-technical issues generating technical solutions; to set out the promises of (at a given moment) new technical solutions and the resulting technical problems justifying (at a later moment) new technical advances; in a word, to point out cross-overs and re-entries between technical and non-technical spheres of TOTS without tracing the entire spiral.

Brain death may again serve as an illustration of this approach: would our study concentrate on the local medical technology of organ transfer (which it does not), then a detailed description of technical change in death diagnosis would be offered. We would show how the prevailing legal definitions of death became impractical and were supplanted by the notion of brain death. We would describe various technical defini-

⁵ For details see Braun et al. (1991).

tions of brain death and the technical steps that allowed for a progressive shortening of the time span required for verifying the diagnosis, and we would point out how this enabled TOTS to step up the supply of transplantable hearts. We would also point to the legal changes required, to ethical debates about the legitimacy of brain death procedures, the resistance of the nursing profession to take prolonged care of dead patients, and the like. Similarly we would point at, hypothetically now, the new push for artificial heart research resulting from mounting public criticism of brain death practice.

We would not, however, inquire in great detail into the processes by which brain death, and for that matter the transplantation of human organs in the first place, became culturally legitimate practice or how, again hypothetically, its broad acceptance began to erode. In other words, we would not retrace in great detail important parts of the movement from initial awe and horror (as pictured in the early movies featuring organ transplantations) to general acceptance plus irritation with non-professional and criminal practice (as reflected in the movies and TV serials of the eighties). While we would deal at length with the technical problems of looking into the brain, we would only indicate the process by which the Christian churches came to officially support (brain-death based) organ transplantation, telling believers that transplantation does not interfere with resurrection and that offering the gift of an organ is a caritative act. We would only mark the effect on the technological agenda of debates linking brain death issues to abortion issues, and transplantation to genetic engineering, debates in which the churches take stands opposite to their support of TOTS (and may therefore help to decrease organ supply, setting in motion further searches for technical ways out).

II. TOTS TECHNOLOGY

TOTS was built up since the late 1970s and is based on (parts of) air and other fast transport systems, telecommunication and computer network systems, as well as various high-tech clinical technologies, both surgical and chemical. Past development of the transplant system has been driven by a chronic undersupply of donor organs see figures 1, 2, and 3). This has caused a series of turbulences in the system. At present, European TOTS confronts a range of problematic issues which have to do with its transnational integration and clearly necessitate further transformations, only some of which can be foreseen with any confidence.

Figure 1

The gap between the number of patients awaiting renal transplantation and the number of patients transplanted

	1968	1970	1972	1974	1976	1978	1980	1982	1984	1986	1987	1988
Total waiting list	211	862	1197	1583	1690	2065	2865	3756	5285	7412	8268	9086
Total transpl.*	54	217	356	606	697	903	1231	1493	2023	2468	2738	2736

*excluding living related transplantations

Figure 2

Distribution of the number of patients awaiting retransplantation (1987)

first graft	6901
second graft	1121
third graft	209
fourth graft	31
fifth graft	6
Total	8268

Figure 3

**Distribution of patients on the waiting list
of EUROTRANSPLANT in relation to the time
since their registration (1987)**

The very notion of second order technical systems implies that the technical substrate of TOTS is heterogeneous and that system borders are fuzzy. Any attempt at classifying and circumscribing must be highly provisional. Ours is motivated by the wish to set out the basic transorganisational network character of TOTS, not to contribute to a description of a much lamented *Apparatemedizin*.

TOTS as Technically-Based Inter-Organisational Networks

In the past, health technology studies have largely been micro in the sense that they focused either on behavioural implications for medical personnel and patients, and the like, or on various health organisations and firms. Also, the technical linkage of clinics and, to a lesser extent, praxes with all kinds of medical apparatus and equipment has drawn attention. At present, inter-organisational networking of these technologies is in full progress. Inter- or supra-organisational networking, as described by industrial sociologists for the machineries operated in turn by producer, supplier and sales companies, is in the process of being introduced in some countries. For the time being, the phenomenon remains restricted to those parts of the health system that deal with finance and insurance and the mostly regionally organised logistics of medical emergency services.

In the context of clinical medicine, TOTS represent therefore a technical development where, for the first time, inter-organisational and transregional technical networks play an important role (see Schoeppe 1989: 27f.). In the following, we will therefore not speak of the "diffusion of transplantation technology" (a notion that might be plausible for instance in cases like the diffusion of computer tomography) but about the large technical system of organ transplantation and its extension.⁶

The technical networks underlying transplantation link a wide spectrum of varied technologies - transplantation specific ones, other medical and non-medical technologies. It links reliable, routinised technologies with experimental ones. Especially, it links highly heterogeneous mechanical, chemical and biological technologies and puts them to work in a host of organisations, in their turn partly medical and partly non-medical, such as transplantation centres and normal hospitals, tissue and organ banks, dialysis clinics and laboratories, transplantation co-ordination and information centres, not least the numerous medical emergency services within the transport, airline and

⁶ For a general critique of the diffusion concept in organisation change research see Czarniawska-Joerges (1993).

telecommunications networks. This linking-up of technologies and their organisations is achieved mostly through existing communication and transport infrastructures.

The resulting transplant organisation is spatially and functionally widely dispersed, requiring a higher level of normalisation as compared to local hospital organisations: regarding the standardisation and compatibilisation of the apparatus utilised across the entire organisational field, regarding data formats, drugs, transport containers, conservation media, surgery and treatment, and regarding routine co-operative exchanges between the component organisations and professions involved (for an example see figure 5). Compatibilisation of bureaucratic formats also serves to legitimate the central control and monitoring of the hospitals involved.

Compatibilisation of bureaucratic formats is in turn highly technical, for instance in the application of standard tests for tissue typification and the exchange of computerised data. PIONEER, the communication system introduced by the Eurotransplant organisation in the late 1980s in order to link all relevant transplant organisations, medical and non-medical, in the participating countries (see Broom 1988), plays a key role in these standardisation processes. PIONEER links on-line 38 transplantation centres and 41 typification laboratories in five Eurotransplant member countries (Germany, Austria, Belgium, Netherlands and Luxembourg) into Eurotransplant's central mainframe in Leiden (see figures 4 and 6). In store are over 100 000 immunological patient profiles, transplantation relevant data of potential recipients (state of health, degree of urgency, treating hospital and so forth), as well as data about results of particular transplantation therapies. Whenever a donor organ becomes available, PIONEER is to initiate the computer-controlled selection of a suitable recipient and, most important, to cross-check regional waiting lists and Eurotransplant's comprehensive lists of aspiring patients.

The operational characteristics of the technically networked transplantational field constrain local organisational autonomy. The pattern is not unlike some military modes of operation: long periods of normal, relatively quiet and entirely routinised clinical activity alternate with short phases of hectic activity where clinical routines and organisational hierarchies are subverted (see Rochlin/La Porte/Roberts 1991 and Rochlin 1989).

During the intermittent phases of slow activity, the network is mainly used for purposes of finding potential donors and donor organs, apart from ascertaining certain post-operative and evaluative functions. As soon as "the net" has identified a suitable donor, a veritable cascade of mostly synchronous activities is released: procurement of consent for transplantation, preparation of ex- and implantation, information exchange regarding donor state and organ specification, matching donor tissue information to

Figure 4

Cooperation between ex- and implantation centers, tissue typing laboratories, EUROTTRANSPLANT and dialyses centers

Figure 5

Standard form for heart explantations

EUROTRANSPLANT NECROHEART REPORT				CENTRE:	
Date:				Contacts to Dr.:	
Phone no.:					
Name of donor:			Date of birth:		
Hospital Dept.:			Date of death: at o'clock		
Sex:	Height:	cm	Body weight:	kg	
ABO-type:			Coronaryangiography: yes / no		
Diagnosis:			Chesttrauma: yes / no		
Day of Admission:		Body temperature:		Bloodpressure:	
Mechanical ventilation since:				CVP:	
Dosage of Vasopressors:		Diuretics:		Antibiotics:	
Diuresis: last 24 hours:		last hour:		Leucocytes: Hb:	
Blood gas analysis: PaPO ₂ :		PaCO ₂ :		K ⁺ : Na ⁺ :	
Hypoxemia: yes / no		ECG pattern:		CK-MB: HbsAg	
Culture Sputum:		Chest-X-Ray:		Chest tube: yes / no CMV:	
Episodes of hypotension: no / yes		Duration: min.; lowest syst. pressure:		mmHg HTLV III:	
Cardiac arrest: yes / no		Hypertension: no / yes:		mmHg	
LAP: mmHg; Wedgepressure: mmHg
Performance of the heart: excellent / good / bad					
Pericardial hemorrhage: yes / no					
Macroscopic visible coronary arteriosclerosis:					
LAD / CX / RCA yes / no; Intra-atrialdefect: yes / no					
Cardiectomy: with / without aortic arch					
Cardiectomy: with / without left and right pulm. art.					
Heparine: at o'clock		Phenoxibenzamine: at o'clock		at o'clock	
Aramine: at o'clock		Others: at o'clock		at o'clock	
Cold perfusion started at: o'clock		stopped at: o'clock		o'clock	
(via ascending Aorta / via innominate arterial trunc)					
Cardioplegic Solution: Bretschneider / St. Thomas / Kirklin / Other:					
Volume of perfusate: ccm;		Perfusion: excellent / good / bad			
Cardiac arrest after sec.;		Cardiectomy at o'clock			
Surface cooling: yes / no		Other Organs retrieved: Liver / pancreas / kidneys			
Storage in (kind of solution): Isotonic Saline / Ringer / Cardioplegic / Other:					
Number of blood units used, until cardiectomy:					
Prospective crossmatch: yes / no		Results: pos / neg			
Copy of Anesthesia protocol as enclosure: yes / no					
Other remarks:					
Name of Recipient:			Date of birth:		
ET-nr.:			Centre:		
ABO-type:			HLA-type:		
HLA-Antibodies:			Direct x-match:		
Blood / Spleen / Lymphnodes / Cells:			Cold Ischemia time: hrs		
Sign.:			Name:		

Figure 6

The netstructure of PIONEER

potential recipients' tissue information in the data pool, computerised selection, physiological compatibility tests, explantation, transport of test tissues, organs, patients, doctors and apparatus, and finally implantation. To the involved local organisations, these activities appear like sudden attacks on the normal day-to-day clinical process requiring in and during a very short time span the mobilisation of all kinds of relevant resources.

Often, conflicts arise from extensive communication needs: supply organisations, co-ordinators and explantation teams are all anxious to keep in touch with their transplantation centre, thereby blocking the telephone system of hospitals that might be ready to offer help. There are plenty of examples illustrating these and similar problems. In some cases they have provoked efforts to formalise co-operation among hospitals.

Systems such as PIONEER operate their networking functions through existing infrastructure systems for long-distance data transmitting. Transplantation operations are therefore heavily dependent on highly efficient networks. But TOTS also depends on close-meshed transportation networks, especially road and air. If the transplant (or the donor's body), the explantation team, the tissue sample and the recipient have to travel only a short distance, which is the case when a patient of a transplantation centre is the recipient of an organ whose donor is available within an area covered by this hospital, it is common to use ambulances or taxis. Yet about one-third of organ explantations make intensive use of air-transport, especially in the case of multi-organ explants where various organs of a donor are brought to separate regional transplantation centres and where several transplantation teams from different centres are involved. Media coverage of transplantation as a rule celebrates this technical aspect. And indeed there is no other field of medicine where everyday work routine is so much determined by jet-setting, by the extensive use of aeroplanes and helicopters. A landing field for helicopters is therefore mandatory, just as hospitals specialising in emergency medicine have them. In the US where greater distances have to be travelled for organ transfers some transplantation centres even have their own small airports.

Apart from modern long distance data-transmitting networks and air-traffic systems, the good old telephone is used extensively and with it the infrastructure of telecommunication. Especially during the busy phases of transplantation, when explantation procedures have to be co-ordinated with organ transfer and implantation procedures running parallel, the telephone is virtually essential. When, due to a software error, the AT&T network broke down in early 1990, transplantation activities largely came to a halt in the US. Participating hospitals could no longer be co-ordinated, and it

became impossible to locate relatives of deceased patients obtaining their approval for donating organs.

TOTS as a Technically-Based Inter-Organic Network

As the acronym TOTS implies, one can see transplanting itself as a networking of bodies and organs. In the process of transplantation a technical network is established between several human bodies. These are usually the body of a deceased person and several bodies of recipients. This act of networking, as we shall see later, holds the critical point for all popular ideas about the questions of life and death. The bodies to be linked with each other are determined through a so-called tissue matching procedure, a trial body-coupling.

The central technical object within this body networking is the organ to be transplanted. The transplant's **technical** character is mostly overlooked in public debates about transplantation medicine. Instead, emphasis is on the morally connotated categories of natural versus artificial organ substitutes (*Organersatz*). But donor organs are themselves prostheses, artificial limbs. As soon as the dead donor body is kept functioning by means of an enormous intensive-care machinery one must speak of these organs as technical products. The intensive care treatment of potential donors means frequent and differentiated control of lab test data in order to monitor metabolic and circulation functions. Their organism, lacking cerebral functions, is controlled by apparatus and medication designed to keep up the functions of the organs to be transplanted later on. In addition, transplanted organs, as much or more so than mechanical prosthetic implants, require continuous technical care and maintenance, and need life-long follow-up examinations, immune suppression medication or immune modulation (see Pichlmayr 1986).

Beyond this, networking of bodies is also taking place on another level. In participating organisations donor and recipient bodies are connected to technical systems and their trans-organisational networks. How far-reaching the connection of professional and everyday handling of bodies is and how far this technical network reaches into its clients' everyday life is vividly illustrated by the beeper system.

When potential recipients, mostly kidney transplant patients, have moved close to the top of a waiting list they receive a beeper. As long as they carry this gadget they can be reached any time and any place, in case a suitable organ becomes available, moving around freely in the meantime. Once they have been called on the beeper they must immediately get in touch with their local dialysis centre and call a taxi to the transplanting hospital or possibly the next airport. Accordingly members of transplan-

tation teams are called on their emergency beepers and moved to the locus of the transplantation.

The networking of bodies extends to **potential** donor bodies - and that means almost everybody. Apart from supporting the transplantation operation and the lasting integration of donors' organs in recipients' bodies, one of the designations of the transplantation system is to procure donor organs. A considerable section of TOTS technical networks therefore serves to provide organs. Or rather, it serves to connect to the system any human body within its reach about to face death.

The technical linkage of donors is for the most part based on virtual capacities of the network, thus augmenting the chances for the recovery of organs. This fact, however, does not help relieve people's fear and bewilderment when confronted with the transplantation system. It is not so much the fear of possibly being a candidate for transplantation oneself or the knowledge of transplantations being performed somewhere. What seems more irritating is the thought (or the fact) that through "virtual networking" everybody has been turned into a potential donor.

TOTS Component Technologies: The Clinical Apparatus

TOTS not only combines various infrastructures of communication and traffic systems. It also combines an extensive, highly heterogeneous range of medical apparatus, instruments, machines, pharmaceuticals and procedures. Some of the more important appliances and their functions in the course of a explantation, organ transfer and implantation may be of interest.

Special medical instruments employed in **explantation** speed up and certify brain-death diagnosis. Electroencephalographs are used to show ceasing brain electric activity and so-called carotesangiograms determine through X-rays whether blood circulation of a donor's brain has ceased.

To non-professionals it is still surprising that an extensive intensive-care machinery (for example for artificial respiration, automatic monitoring of circulation) is of the greatest importance not only for implantation but for explantation as well. Quite often this machinery is used to keep up metabolic functions and the circulation of brain-dead donors until the organs are ready to be explanted. The purpose of the procedure is to shorten the phase during which an organ is already cut off from blood circulation but not yet refrigerated ("*warme Ischämie-Zeit*"). This technical complex accounts for the minimum time spans required by present transplantation techniques and particularly for reducing the likelihood of organ damage before finding suitable recipients. It also

accounts for much debate, not the least at the level of those who "take care of dead patients."

Explantation itself is of course a matter of straightforward surgery. For the explanation of frequently to be transplanted organs, however, specific techniques and instruments (such as special catheters, artificial nutrient fluids or medication to prepare transplants for implantation) have been developed. For kidney transplantations these are, for example, "en-bloc-nephrectomy" or "in-situ-perfusion," aimed at adjusting the transplant to artificial nutrient fluids while still in the donor body (see figure 7). This is to secure a gentle treatment of the organ during explantation and, again, to gain precious time for organ transfer and implantation.

Most of the technical devices used in **organ transfer** are conditioned by the limited time span during which organs remain transplantable. Time is inscribed, as it were, into the entire technology. Donor organs are kept in fairly simple refrigeration containers and are provided with a Europe-wide standardised nutrient fluid. Tissues samples travel in special aircraft. Bones, corneas and marrow can be preserved through special cyrotechniques. Hearts, kidneys and livers can be kept in refrigeration containers only for a short period of time. More efficient and refined conservation techniques are only beginning to be put into practice. The development of so-called transplantation survival systems, which will allow the build-up of organ banks, might further ease time-dependency.

An enormous amount of technical apparatus is needed for the typification of tissue samples of donors and recipients prior to the transfer of organs. Tissue samples are collected in special glass containers and sent to specialised laboratories able to decode tissue characteristics through standardised serum tests. Performing and analysing these rather expensive and, alas, time-consuming tests requires increasingly specialised automated machinery producing up-to-date versions of recipients' possibly changing immune profiles. Genetic methods of typification, promising more precise decoding of tissue characteristics, are not yet in use - because so far they simply take too much time.

Tissue compatibility is ascertained through special methods, in the first place to preserve the tissue, and then, if there is enough time and an immunological necessity, to match tissues. Tissues of donor and recipient are brought together in order to estimate immunological adaptability. Sample tissues of all patients are always in store at the tissue banks of transplantation centres for this purpose.

Mechanic substitute organs, such as artificial hearts, artificial kidneys and pulmonary machines play their role in organ transfer (see figure 8). At present, "artificial" organic and mechanic organ substitutes compete only in the therapy of

Figure 7

**In-situ-perfusion catheter (left),
a kidney ready to be sent (right)**

Figure 8

Functional scheme of an artificial kidney

kidney insufficiencies. For the most part "artificial" organs and "artificial artificial" organs complement each other and add to the transplant survival systems mentioned above: for a short time they substitute for the human body until a fit recipient has been found. Correspondingly, artificial hearts and pulmonary machines, and in some cases artificial kidneys, play substitute for a particular organ until the recipient receives a transplant.

The implantation of mechanic substitute organs relieves the time pressure normally caused by patients' state of health. With a mechanic substitute organ a patient may survive the crucial period from the moment of organ failure to the moment a suitable substitute organ becomes available. In the professional jargon: they are "bridging-organs".

Intensive-care machinery and techniques and methods of implantation surgery are of course both important for **implantation**, too. Recent achievements in vascular surgery have made implantation a routine operation. At the beginning of the 1980s, implantation of kidneys took several hours; at present, under the right conditions, it can be performed within twenty minutes.

After the implantation, technical appliances and procedures applied aim at stabilising a successful transplantation, helping to prevent transplant rejection. Laboratories again play an indispensable role here. Tissue and blood samples must more or less continuously to be analyzed to foresee or diagnose rejection crises.

The manipulation of body reactions is achieved exclusively through chemical devices. One type of "appliance" are genetically generated monoclonaric antibodies, counteracting acute rejection risk. More widely used is the drug Cyclosporin and the newly developed FK 506, both designed to not only avert dangerous rejection reaction but also to reduce the creeping destruction of transplants caused by recipients' own immune system.

Next to the techniques of tissue compatibilisation mentioned above, it is Cyclosporin which plays a key role in transplantation medicine. Conventionally treated patients, says the literature, have a 55 % chance of living through the first year after transplantation with their new transplants. Now that Cyclosporin A is generally available, over 90 % of the transplants pass this test. At present, even after four years almost 80 % of the transplants still fully function, compared to less than 50 % when Cyclosporin is not used for immunosuppression therapy (Pichlmayr 1986: 159). FK-506 is expected to allow for even more effective immunosuppression therapy.

An interesting aspect here is that system growth feeds on system growth: chemical intervention to preserve organs ruins other organs, calling for replacement in due time.

The Technical Fringes of TOTS

The example of the various radio systems used to coordinate transplantation activities has shown how difficult it is to define the technical components of the transplantation system. A closer look, however, reveals that transplantation - just like any other large technical system - is interwoven with all technical installations of modern societies - seamless in this respect, too. By this token, the technologies concerned are variously employed outside transplantation. One would, in other words, not ordinarily describe them as being "part of this system." As a technical framework, however, they do sustain and shape transplantation.

Seemingly marginal technical phenomena are particularly prominent at the level of organ supply. The largest group of donors are accident victims (see figure 9). Technical features of types of accidents--household, traffic, workplace--are reflected in organ supply and demand. Motor biking, for example, is considered a "net-organ supplier," meaning that bikers belong to a group of people, defined by age, and way of life and death, which potentially supplies more organs than are needed by this same group. The rather grotesque reason behind this classification is the supposedly healthy age of these victims and the fact that most organs will remain uninjured during the accident. People dying in car accidents are usually locked in the car wrecks, often suffering burns and organ lacerations. Motorbikers are flung into the air and suffer mainly head injuries. The particular circumstances of motorbike accidents happen to coincide with the criteria of organ qualification in organ explantation: desirable are uninjured organs of younger donors whose brain death can be ascertained quickly and surely, before other organs suffer damage. As the saying goes, "motor cycles are donor cycles"--brains not yet being in high demand for transplantation.

Antecedent everyday medication affects transplantation in many ways but pharmaceutical technology gains considerable importance at the demand side, when drugs lead to irreversible organ damage which can then be treated only with transplants. The successful application of certain medications in long-term therapies of diabetes, rheumatic diseases, and allergies are apt to ruin kidneys. Transplant physicians' clients are sometimes sent by colleagues from other fields of medicine. Cyclosporin which has to be taken by transplantation patients for the rest of their lives in order to suppress rejection is damaging the kidneys, too, which in turn accounts for the promises of a new drug, FK-506, supposedly guaranteeing sufficient immunosuppression on doses kidneys can handle.

Figure 9

Donor age distribution and cause of death (1987)

Accidents not only supply organs: a continuous, if fairly low demand for donor organs results from them, in particular from traffic accidents. The largest share results from chronic and age related diseases. Disastrous accidents taking place in large technical systems, such as mass collisions on highways, airline crashes or the disaster of Chernobyl, put a strain on national and international transplantation systems. Large technical systems operate on both sides: they cause disaster and help handling them.

III. TRANSBORDER ISSUES IN TOTS

According to large technical system historiography, classical technical infrastructures have been built up in a rather erratic, though clearly expansive bottom-up dynamic. Historical texts as much as ongoing social narrative usually employ an evolutionary rhetoric in describing their growth. In this view, the starting points of a system build-up are different local centres for demonstration and experimentation. These are then linked up step by step into regional networks, which in their turn are integrated into national and in the end international infrastructural systems.

Together with an increase in regional scale, the organisations controlling the networks, and state interest in these organisations, grows. Underlying technical change is conceived of as a scaling-up process, too, familiar smaller scale technologies being enlarged and adapted to the operational requirements of massively networked structures.

Top Down Expansion

The story of TOTS is a little different. The first organ transplantations were performed in the seventies at the very top of national health systems, in the context of marvelously funded research projects located in the best clinics. Accordingly, the medical technology used was experimental. For many areas of transplantation medicine this is still the case.

Since effective immunosuppressive drugs were not yet available, early organ transplantation consisted mostly of kidney transfers between close relatives. Only now and then other organs coming from non-relatives or dead donors which happened to be sufficiently compatible were transplanted. Regional and international organisations devoted to targeting suitable transplants had not yet been established. The donor pool was limited to the area covered by a particular hospital where the research project was located. Transplant exchange took place mostly on the level of international research

groups. The few transplantations occurring with organs not coming from relatives resulted from such international exchanges. Co-ordination of traffic and communication between participating organisations, nowadays formalised routine, was more or less improvised.

The formation of the international Eurotransplant Foundation in 1967 exemplifies how transplantation medicine took off from an international level. During the first years its main tasks were to initiate research in all member countries in transplantation-related medicine (such as vascular surgery, histology and immunology) to co-ordinate on-going clinical research projects and to assist with the supply of donor organs. By the seventies most of the surgical difficulties had been overcome, tissue matching had been mastered and the creeping destruction of transplants could be met by suitable drugs. This was the time to establish a technical-organisational network on national and later on also on lower regional levels (figure 10 gives figures for the Eurotransplant). To be sure, the physicians involved did not have to start from scratch. Organisational means of networking were provided by existing reference systems. These were facilities for kidney analysis, blood donating and emergency-rescue services, which were all well developed and widespread in most industrial countries.

Transplantation surgery early on was shaped by a few outstanding physicians. The first to transplant a kidney in the late sixties, Joseph Murray, laid the foundations for tissue-matching and immunosuppression. Liver and lungs were first transplanted by Thomas Starzl and James Hardy in 1963 and Christian Barnard pioneered transplanting a heart in 1967, an event that triggered an unprecedented coverage in the media. These physicians, however, do not really match the notion of "system-builder" put forward by Thomas Hughes. Dedicated doctors, non-profit organisations and private foundations joined in pushing ahead the building of the technical network of today's transplantation practice. It is interesting to note that especially non-medical organisations, and in particular associations of potential users (associations of heart and kidney patients and their relatives), have greatly contributed in setting up the system.

The growth of TOTS has little in common, then, with the history of classic infrastructure systems. It resembles more the process of expanding infrastructure systems by adding special subsystems, such as the addition of certain facilities of combined street/rail goods traffic to the existing railway system, or the expansion of an existing broadcasting system by adding facilities for long-distance data-communication to an existing telephone system. Mayntz and Schneider, for instance, point out in their study on the introduction of video text in France, England and Germany that it did not spread

Figure 10

Worldwide registered heart transplantations per year

from local islands but that it was prospectively mapped out and planned, and that it was centrally controlled and systematically pushed forward.⁷

System Differentiation: De-nationalising or Nationalising?

In the final analysis, incongruities and disparities between organ supply and demand are due to a certain biological fact: that human bodies are highly incompatible. This fundamental tissue incompatibility is the very basis of international organ transfer. For, if the immunologic fitting of donor and recipient tissues were not relevant for transplantation, one might assume that national or sub-national systems only could assure sufficient transplant supply.

This suggests that the present task of TOTS in large part consists in the compensation or at least the attenuation, on an internationally enlarged scale, of regional and national tissue incompatibilities and in solving the resulting allocation problems (for the German case see figure 11). At the same time, specific systems dynamics in part threaten its international character and vary its action radius. The instability is mostly due to spatially and temporally dissimilar development of contributing subsystems and technologies. The relative number of transplants that have to be procured internationally decreases as national and regional systems are developed in the countries from which transplantation surgery originated. The requirement of international organ exchange is also decreased by results of immunological research. Immunosuppressives such as Cyclosporine help in attenuating the compatibility requirements which must be met by donor and recipient tissues (see Braun et al. 1991). Finally, the international system is increasingly by-passed by experiments with animal transplants, so-called auto-transplantation and human-biological cryotechnologies. Also, the development of tissue-culture transplants is beginning to benefit from the latest achievements in genetic engineering research.

Legal adaptation of different national definitions of life and death as well as organ donation regulations occasioned by TOTS act in similar ways. In the Netherlands, for instance, the explicit consent given by donors during their lifetime is a prerequisite for organ explantation: a condition that impedes organ procurement. In neighbouring Belgium organs can be recovered in principal from all dead persons who have not, during their lifetime, explicitly opposed explantation. As a consequence Belgium

⁷ Mayntz/Schneider, however, tend to consider videotext (BTX) as an autonomous LTS beside the telephone and other systems, not just an extension or addition to the existing telephone system (see Mayntz/Schneider 1988).

Transborder kidney exchange in Germany (1988)

supplies more organs to the Dutch than vice versa. When such national differences are levelled out, the extent to which donor organs have to be transferred between different countries is decreased accordingly.

Counteracting such nationalising effects, trends favouring further expansion of supranational TOTS can be observed. Increasing routinisation and simplification of transplantation surgery result in more and more countries taking up this branch of medicine. Frequently, this happens before an adequately dimensioned donor system is built up. In fact, the establishment of a comprehensive, culturally accepted and politically safeguarded donor system requires a considerably longer preparatory period than the build-up of transplantation clinics which are solely used for implantation. As a consequence, the transplantation medicine of newcomer countries remains in its initial stage dependent on international organ supply systems.

More sophisticated transplantation surgery goes hand in hand with differentiation processes in organ demand. With regard to more popular donor organs such as kidneys, and to a certain extent hearts and livers as well, it is not only the availability of some transplant that matters, but more and more that of **high-quality** transplants. This means above all organs from donors who are as young as possible. Donor-organ quality requirements which are not specifically dependent on immunological necessities seem to become more exacting, narrowing the logistic margin opened by the lowering of biological tissue-compatibility requirements and recreating new incompatibilities premised on non-medical criteria.

Technical achievements in immunomodulation and transplantation surgery permit the gradual extension of the range of routinely transplantable organs (see figure 12 on the state of the art for specific organs). As a consequence, for each newly admitted organ - such as spleen, brain tissue, pancreas, lungs, testes, ovaries and bone marrow - the initially required transnationality could be restored. Eventually, the most important stimulus for maintaining international system integration may be a specific change in function which has been affecting transplantation systems since the late 1980s. The logistics for recipient selection were established in the 1970s on the basis of the medically and logistically necessary large-area tissue compatibilisation imperative at the time. With the availability of ever more effective drugs for immunomodulation, they were turned over to monitoring activities, increasingly performing functions of verification and legitimation. More and more they support establishing economical and other non-medical selection criteria, facilitate keeping undue competition between transplantation centres under control, monitoring transplantation and organ assignment practices which differ widely between countries and clinics, and the like. In the words of Rudolf Pichlmayr, one of the most prominent German transplantation surgeons:

Figure 12

State of art in different transplantation fields

Organ	Durchführung			Therapeutische Stellung
	weltweit gesamt	BRD gesamt	BRD jährlich	
Niere	> 200 000	~ 13 800	1778 (1988)	Methode der Wahl mit hohem Erfolg (bei enger Indikation) mit zunehmendem Erfolg bei angemessener Indikation
Herz	~ 9 000	~ 700	209 (1988)	
Leber	~ 5 000	~ 550	163 (1988)	
Herz-Lunge	~ 430	8	5 (1988)	noch in Entwicklung
Niere + Pankreas	~ 2 000	~ 150	41	
Pankreas			8 (1988)	
Knochenmark	> 5 000	~ 800	~ 400	klinische Behandlung
Cornea Gehörknöchelchen Knorpel	(sehr häufig)			klinische Behandlung

"What initially was meant to assure organ compatibility, the optimum fitting of donor and recipient, has now become an excellent tool for monitoring ourselves" (Pichlmayr 1990, p.229).

A need for monitoring is also evidenced by complaints of transplantation physicians about deteriorating standards in international organ exchange, having to do with an anticipated decrease in importance of tissue compatibility. Apparently, physicians may work less diligently when explanting and conserving transplants destined for other centres in TOTS than for in-house transplantations (see the problem list in figure 13).⁸ Yet another aspect in this context is an increasing *Patiententourismus*. In recent years, the uncontrolled international and inter-regional movement of patients seems to have come to be seen by insiders of the system as much more of a problem than the import/export of organs which is so critically observed from the outside.⁹

In our view, a solution to the contervailing interests and requirements concerning the issue of operational range or reach is to be seen in a functional differentiation within TOTS. Internationally integrated system levels will probably be oriented to more general, less organ-specific tasks than previously. They will essentially be limited to the monitoring functions described above and to operating the exchange of more or less exotic donor organs, for more or less experimental purposes: organs that are so seldom transplanted and for whose supply systems with a national radius would be insufficient or too costly, as well as transplantations considered to serve research rather than routine therapeutic purposes. This may include organs needed for acutely life-threatening special patients and innovative transplantations that must meet extraordinary requirements in terms of tissue compatibility or legitimation.

For the transfer of less exotic organs and transplantations which are technically routine and medically legitimate, relatively stable and organ-specific systems will be established on national and even local levels. The situation can be compared to the modal-split problems encountered in traffic and communication systems undergoing a process of differentiation such as the distribution of traffic flows onto individual and public transport systems or of TV transmissions onto cable and satellite systems.

⁸ Introduction to *Zeitschrift für Transplantationsmedizin*, 3, 1991, by Arno-E. Lison.

⁹ On the international organ trade see Pater/Raman (1991).

Figure 13

Typical problems of interregional transplant activities

Problems with regard to multi organ donor/transplant activities in the last quarter of 1988

October 17, centre 1 reported that liver patient X was transplanted with a donor from centre 2 already on October 6! As this donor was only known as a kidney donor, Eurotransplant contacted the transplant coordinator of donor centre 2. It appeared, that also the heart of this particular donor was transplanted in a patient from that donor centre 2. Conclusion: Both patients (liver and heart) have unnecessarily been registered on the waiting list for more than two weeks after transplantation.

On October 26, a donor heart was offered to a patient with urgency 1. There were two other urgency 1 patients from other centres, but with a shorter waiting time. One day after the transplantation, the transplant centre was contacted and it appeared that another patient from that centre (urgency 2 category) was transplanted!

Centre 3 transplanted a donor heart from a local donor without contacting the central Eurotransplant office in order to check whether there were any urgency 0 patients. And indeed they were there.

Similarly on November 12, centre 4 transplanted an urgency 2 heart patient with a local donor without checking the high urgency file. Moreover, the blood group of the recipient was A, while the blood group of the donor was O. At that particular moment, there were 22 urgency 1, blood group O heart patients on the ET waiting list!

On November 28 centre 5 had a multi organ donor of which heart and liver were transplanted locally. The heart recipient was registered under urgency 1, the liver patient was registered under urgency 2. On the Eurotransplant central waiting list urgency 0 patients were available heart as well as liver patients!

On November 30, centre 6 transplanted a donor liver with a local recipient although high urgency patients were available in Eurotransplant.

On December 1, centre 7 transplanted a donor heart locally in an urgency 2 recipient although 15 urgency 1 patients were on the waiting list.

On December 3, centre 9 got an offer for a liver recipient who is registered on urgency 1. One day after transplantation, the Eurotransplant office contacted the transplant centre and it appeared that this centre has transplanted an unknown new liver patient who has not even been registered on the waiting list!

On December 16, centre 10 transplanted a donor liver in a local recipient (urgency 2) although there were numerous recipients waiting within Eurotransplant with a higher clinical urgency!

Problems with regard to multi organ donor/transplant activities; March - May 1989

On March 22 and on March 25, center 1 had a multi organ donor of which the heart was transplanted locally. The recipients were registered under urgency 2. On the Eurotransplant central waiting list there were several urgency 1 patients available.

Similarly on March 26, center 2 had a multi organ donor of which the heart was transplanted locally. The recipient was registered under urgency 2. On the Eurotransplant central waiting list there were several urgency 1 patients available.

On April 1, center 3 offered directly a heart to center 4 without consulting the central Eurotransplant waiting list. The patient who was transplanted was registered on the central waiting list under urgency 2 while several patients with urgency 1 were available; among them even two patients were very urgent.

Like the first two centers two other centers transplanted a donor heart locally into an urgency 2 recipient while several urgency 1 recipients were available; and even another center transplanted a donor heart to an urgency 3 recipient.

On May 25 again there was a case listed similar to the first two cases. No further comments seem necessary.

On July 12 center 5 reported a heart transplantation they performed on an urgency 1 patient, but the donor was only reported to Eurotransplant some days later.

IV. TOTS AS SECOND-ORDER LARGE TECHNICAL SYSTEM

Keeping close to our illustration, we will now examine structural differences between transplantation systems (and other second-order systems) and associated transport and telecommunication systems (first-order systems) on which the former are based. We will then discuss in more general terms certain repercussions on the development of first-order systems (such as transport and telecommunication systems) from the progressive build-up of second-order systems (such as TOTS).

Interdependent Technical Heterogeneity

TOTS represent large scale technical systems, much as classical infrastructural systems, for the following reasons:

- because TOTS' assigned functions are executed mainly through pre-existent technical networks spanning large spatial and temporal distances;
- because their operation is a precondition for the functioning of a large number of small technical systems;
- because a large number of societally important non-trivial operations are carried out via their networks;
- because they relate many different, otherwise largely unconnected organisations and actors.

At the same time, however, the example of TOTS suggests a series of differences.

- Transplantation networks are heterogeneously recombining other networks.
- Where classical infrastructures are geared to a multitude of different uses, organ transplantation systems are limited to very specific tasks;
- TOTS and similar systems can claim only little technical or organisational "proper substance."

The latter point means that their technical networking and their supra-regional operative scope to a large extent depend on services rendered by classical infrastructures, in particular telephone, data communication, road transport and aviation, both civil and military. TOTS networks are largely borrowed from other, more extensive technical systems. The "proper" contribution of TOTS to networking consists then mainly in a purposeful **combination** of existing infrastructural facilities. In this process, TOTS operators not only use each infrastructural system as it is used by any household or business, but to a certain extent intervene in the operation of the linked systems. For instance, they secure preferential treatment with airlines for the transport of medical

personnel and patients, they run rental jet planes, they enjoy privileged access to emergency services or to various telecommunication facilities.

In short, first-order and second-order systems are similar in terms of the scale of the technical operations carried out through these systems as well as in terms of the spatial range of their frequently international operations. They differ in so far as second-order systems are set up in view of specific purposes and possess relatively little technical/organisational proper substance (scope).

First-order systems are relatively well insulated from malfunctions in other systems with which they are interlaced or linked. When the telephone system breaks down, travellers can still use railroads, even though it may be more difficult to plan further activities at the point of destination. If railroad personnel goes on strike, people can still use cars, even though in such a situation serious traffic congestions are to be expected. Second-order systems, on the other hand, are more prone to functional failure, that is they depend to a considerably greater extent on the **simultaneous** functioning of classical infrastructural systems. Organ transplantations can be delayed or prevented by the collapse of just one of the infrastructural elements involved.

In other words, by linking first-order systems, not only their levels of performance but also the problems inherent in the operation of each system are (at least in part) combined and accumulated. For this reason, second-order systems are generally more vulnerable and articulate a need for relatively higher degrees of standardisation. One net result of these features is that second order systems tend to change more rapidly than first-order systems.

Little proper technical substance of second-order systems also contributes for their relatively rapid establishment and change. Second-order systems are temporally more flexible than first-order systems. The West German TOTS was drawn up in little less than a decade - a relatively short span of time when compared with the time required, for example, for the installation of nation-wide power or water supply systems. Nor will it be easy to find in the realm of classical infrastructures a parallel to the rapid functional change of TOTS in the second half of the 1980s.

Co-evolutionary Effects

How does progressive superimposition of second-order systems on classical infrastructures affect the latter? As second-order systems utilise existing infrastructures in new ways, it is almost self-evident that their build-up goes hand in hand with growth prospects and higher performance requirements for each of the combined infrastructural systems. Thus, in (joyful) anticipation of massive expansion, in the second half of the

1980s the German Telekom solicited the interest of certain companies and industry associations by explicitly referring to the new possibilities of long-distance networking in the context of the telecommunication services to be provided by ISDN. It even asked potential customers to come up with imaginative solutions of their own. (The financial burdens of German unification considerably hampered these attempts.)

On the other hand, traffic planners are concerned about the increased requirements on performance resulting from the introduction by big industrial enterprises of just-in-time-production regimes, shifting product stocks and associated costs onto roads which were already heavily loaded with freight traffic. In Germany, it is now argued that freight carriers should pay more for road system extension and maintenance.

Second-order systems partly affect first-order system operation and thereby potentially stimulate infrastructure innovation and flexibilisation. Developed and financed largely by private-company associations, new German systems of freight-train utilisation and wagon monitoring are currently being established. TOTS, too, can serve as an example of first-order system innovation effects triggered by second-order system development: in the 1980s it pioneered the Europe-wide use of paging devices and long-distance data communication.

Finally, as second-order systems combine the operation and utilisation of different types of infrastructures, they may facilitate convergence in infrastructural developmental levels. This speculation assumes that internal mechanisms repairing Hughes' "reverse salients," considered a central feature of classical infrastructural systems, are also operating in second-order systems.

Technical Homogeneity, Zero-Order System, Interconnections

In general, the concept of second-order systems is meaningful only when the underlying notion of the large technical system is in this sense maintained within certain limits of specification. Speaking of "the" large technical transport or energy-supply system, for example, is much too unspecific, as the margin for potential combinations here is too narrow. On the other hand, speaking of the large technical bus-shuttle system of Linköping Airport or of the large technical electric power grid for industrial consumers at Vadstena is too specific - the margin for combinations here being too wide. The notion of second-order systems is potentially useful when the large technical system concept is located at an **intermediate** level, permitting, for example, distinctions among the large technical systems of spatially extended railway and road traffic, gas and power, water and sewage utilities.

In distinguishing between first-order and second-order systems we apply as a major criterion, next to specificity of purpose, **technical homogeneity**. Tacitly, the large technical systems literature has assumed that normally these systems can be treated in relevant aspects as technically homogeneous. In other words, they are distinguished from each other on the basis of characteristic, unmistakable core technologies. With some systems it is comparatively easy to agree on the typical network technology. For railways it is rails and trains; for road transport roads and automobiles; for power grids cables and electricity, and so forth. But even for systems whose technical network structure is less massive, less uniform, or simply less apparent (such as in air traffic or non-cabled telecommunication systems which some sociologists still tend to treat as "immaterial" networks because they can't see the radio waves and air routes) this approach to system classification raises difficult problems. Solutions derived from engineering literature fail because here the nexus between technical and non-technical aspects of systems is almost systematically effaced.

Provided such problems of empirical delimitation can be solved, the concept of first-order and second-order systems can be supported and extended by **radicalising the criterion of homogeneity**. First, following Ekardt's suggestion (1993) and not starting to look for different technologies typical of different large technical systems, one could look for the one technology common to all large technical systems. Indeed, with **structural engineering and the construction industry** we have a type of infrastructure that the large technical system debate, despite its predilection with construction and system building, has hitherto almost totally neglected. In order to emphasise the complementarity of such large technical system substructures in relation to second-order system superstructures, Ekardt has named them **zero-order large technical systems**.

These zero-order large technical systems above - or more aptly below - all account for the ever deeper penetration of technical systems into their ecological base. By the same token, the conceptual "excommunication" of this zero-order social level helps in keeping consistent a currently fashionable theory that an era of heavy technological burdens on the environment is now turning into one of environmentally more benign technical "dematerialisation," heralded mostly by innovations made possible by telecommunication large technical systems. Sherman and Judkin (1992, p. 151), for example, conclude from their studies of information technologies that "(c)ompact, highly cabled electronic offices will replace the large corporate office blocks which will stand only as monuments to previous business philosophies Not a happy thought for the construction industry." Pruitt and Barrett (1991), having discovered the

"virtual workplace", find that it will be only situated where the workman (sic) is situated, namely in cyberspace (which is both global and fits into a tiny electronic box).¹⁰

The next step toward a more general explication of the second-order systems concept sets out more explicitly the **interconnection** phenomena central to these systems placing them within the endless spectrum of potential interconnections of seamless webs. Note here that second-order systems as much as first-order large technical systems refer to (extra-somatically based) technical interconnections as opposed to non-technical ones such as economic, organisational, and other institutional links. As with non-technical links, there are different types of technical interconnections, depending mainly on whether they connect **technological cores** or rather **peripheries** of large technical systems. The first case is the coupling of single nodes (or node connections) of two (or more) utility networks, with one of the involved systems playing the role of the user and the other that of performance supplier. Correspondingly, one of the two is in charge of establishing and operating the interconnection. In the case of railway network operation for example, power grid connections are through special transformer stations, and conversely, power grid fuel supply is insured through special rail links. Such point-specific system fusions can be found in all large technical systems. Normally, they do not affect the utilisation of the interconnected systems in any significant degree, and in this sense one might say that all large technical systems are second-order in the first place.

The other case is the technical coupling of the loose network ends. It is not really a case of interconnected large technical systems, but of some user organisation being in charge of establishing and operating interconnections. In this sense, firms and households establish links between the infrastructure networks accessible at production sites and homes, interlinking, for example, power, water and sewage grids for the operation of washing machines. Again, such point-specific interconnections are a prerequisite for the operation of most small technical systems, and normally they do not affect significantly their mode of operation.

Second-order systems can be positioned halfway between these two poles. For here not only loose network ends, but also the cores are technically linked, and the organisational competence for establishing and operating the interconnection lies outside the large technical systems involved. Thus, in technical terms, they are situated between the interconnected large technical systems; in organisational terms they are situated between large technical system operators and users. The concept of second order large

¹⁰ For more of this see Sotto (1993).

technical system is meant to emphasise this doubly hybrid character (figure 14 gives a graphic representation of the concept).

Co-Evolution of First and Second-Order Systems

The utility of conceptualising a particular type of large technical systems in terms of their heterogeneous technical linkages remains to be shown. It requires analysing their behaviour over time and showing that the development of different types of large technical systems is interrelated in a way that validates these distinctions. Does the distinction help us understand the evolution of large technical systems in general insofar as the development of first-order systems and that of second-order systems are interrelated in theoretically interesting ways? We will briefly point at three possible answers that are compatible both with the TOTS case and with the concept of second-order large technical systems outlined so far. We will call the three versions the contingency, the precursor, and the differentiation theses.

The **contingency thesis** is the most conservative because it maintains that first-order and second-order systems develop independently of each other. In this view, first-order systems are an evolutionary precondition of second-order systems. Or else second-order systems are evolutionary by-products of first-order systems. Potential co-evolutionary effects are limited to the above-mentioned growth, innovation and convergence dynamic. The strong claim of this thesis lies mainly in the assumption that second-order systems are on a par with other large technical systems - that they can be regarded as a large technical system type in their own right. Accordingly, major conceptual problems have to do with delimiting and comparing both system types.

The **precursor thesis** views second-order systems as independent in a restricted sense only. In accordance with the general rule that new technology most of the time develops out of old technology, second-order systems are understood here as precursors for new large technical systems; new (first-order) systems can but must not necessarily develop out of them. According to this thesis, second-order systems tend to become less purpose-specific and technically more homogeneous. Thus, in the end, the number of first-order system species increases in an incestuous way. In support of the precursor thesis, the genesis of some classical infrastructure systems can be cited. For instance, the first railway lines were still comparatively purpose-specific facilities for bridging gaps in transportation (that is for establishing links between the then existing road and waterway networks). One conceptual challenge here lies in demarcating small and large technical systems. Does it make sense to distinguish second-order systems

Figure 6

Coupled and interlinked large technical systems

interlinked corporate structures

coupled utilisation structures

second-order large technical systems

from extended configurations of small-scale technical systems and which non-incestuous developmental paths lead from smaller to larger technical systems?

The most radical of the three propositions, the **differentiation thesis**, views second-order systems not as characteristic of the earlier stages of systems development, but rather as indicative of a new phase in the history of large technical systems in general. In agreement with another rule of thumb, namely that new technology is a model and a precondition for the further development of old technology, the thesis assumes that first-order systems tend to become more purpose-specific and technically more heterogeneous over time, metamorphosing into second-order systems. Thus, in the end the small number of purpose-unspecific large technical systems would be replaced with a frayed tissue of multiple large technical system phenomena only distinguishable on the basis of their specific purposes. Basically, this assumes that the organisational de-monopolisation, dispersal, and deregulation typical of the late growth of large technical systems will be followed by technical heterogenisation. This would possibly lead not to new organisational orders (smaller, decentralised units) but to a "new loss of orientation" (*neue Unübersichtlichkeit*¹¹) in the large technical systems landscape. There is evidence for this view in findings on the more recent modernisation of large technical systems such as air traffic and telecommunication (for the case of German telecommunication see Kubicek 1993). The conceptual challenge of this line of reasoning comes from the difficulty of distinguishing large technical systems from each other and from smaller systems irrespective of the technologies in question, i.e., solely with reference to system goals and functions and to the organisational processes involved.

V. RESUME

Organ transplantation shares with a large number of other "late" industrialist societal subsystems an essential dependence on large-scale, networked operations, both technical and non-technical. We have given, in the above, two meanings to the term large-scale: one concerning the aspect of a highly dispersed, non-local (more specifically: transborder) temporal and spatial reach; the other concerning the systemic aspect of interdependent technical heterogeneity. This second aspect was highlighted as constituting a particular type of technical system which we named, for present purposes, second order large technical system.

¹¹ A term famously introduced by Habermas to suggest the latest condition of modernity, implying either that systemicity is lost or that it escapes us

The build-up of the European organ transplantation system is a story of continued expansive moves meant to solve chronic structural problems resulting in great part from persistent organ scarcity and time pressures. We have drawn attention to a great variety of such moves, each promising the solution of specific technical or legitimacy problems induced by earlier moves. We have indicated where technical reconfigurations produced cross-overs into non-technical problem areas and where non-technical moves produced re-entries into technical layers of TOTS. The system has been extended fast in the past 15 years or so. The up-scaling of its technical network of networks, largely parasitic on existing technical infrastructures, together with ever more effective immunosuppression, was (in the terms of its interested parties) very successful. So successful that, at the time of this study, its future course has become uncertain. The technical networking of organisations, organisms, and organs will certainly go on, but might be put to different uses: monitoring, verification, legitimization.

The consecutive technical moves to mobilise more organs and to gain time in transplanting them, always justified by the need to close the gap between organ demand and supply, have in fact led to a widening of the gap. Year by year more and more kinds of organs could be procured, but year by year more people with more kinds of indications came into the system. TOTS is a growing large technical system, of the second order, driven by the technical solutions to problems arising from technical advances and by the particular cultural accommodation of this dynamic, reproducing at each stage on a larger scale the problem that has set it in motion. There is little reason to expect that this basic dynamic of TOTS will lose momentum in the foreseeable future.

In telling the story of TOTS, we have used many terms and rhetorical devices generated by those agencies who manage or otherwise legitimately speak for the systems under study. While this is almost inevitable in studies based primarily on written documents, it should be noted that the practice produces a considerable "systemic bias": the kind and degree of "systemicity" (Svante Beckman) described in our study is generated within certain layers of the system and more or less successfully imposed on others. In the life world perspective of the crashed motor cyclists donating (as it is called in some parts of the system) their hearts, the system presumably appears less well structured. Generally, we must assume that the underside of the seamless web shows more loose ends and blurring of patterns.

REFERENCES

- Braun, I. 1993. "Geflügelte Saurier. Systeme zweiter Ordnung: ein Verflechtungsphänomen großer technischer Systeme." In I. Braun/B. Joerges (eds.) *Technik ohne Grenzen* (forthcoming).
- Braun, I., Joerges, B. 1990, "Körper-Technik: Zur Wiederkehr des Körpers durch technische Erweiterung." In *Argumente*, Sonderband 182, 83-104.
- Braun, I., Joerges, B. 1993, Große technische Systeme - erzählt, gedeutet, modelliert. In I. Braun/B. Joerges (eds.), *Technik ohne Grenzen* (forthcoming).
- Braun, I., Feuerstein, G., von Grote-Janzen, C. 1991. "Organ-Technik: Technik und Wissenschaft im Organtransplantationswesen". In *Soziale Welt* 4, 445-472.
- Broom, G. 1988. "Further information on PIONEER". In *Eurotransplant Newsletter* 53, 10-18.
- Czarniawska-Joerges, B., 1993, *The Three-Dimensional Organization: A Constructionist View*, Lund: Studentlitteratur.
- Ekardt, H.-P. 1993. "Bautechnische Infrastrukturen. Beschreibung eines unvollständigen großen technischen Systems." In I. Braun/B. Joerges (eds.), *Technik ohne Grenzen* (forthcoming).
- Joerges, B. 1988. "Large technical systems: Concepts and Issues". In Mayntz/Hughes 1988, 9-36.
- Joerges, B. 1992. "'Große technische Systeme': Zum Problem der Maßstäblichkeit und Vergrößerung in der sozialwissenschaftlichen Technikforschung". In Bechmann, G., Rammert, W. (eds.), *Großtechnische Systeme und Risiko*, Jahrbuch Technik und Gesellschaft 6. , 34-60. Frankfurt/New York: Campus Verlag.
- Kubicek, H. 1993. "Steuerung in die Nichtsteuerbarkeit - Zur Entwicklung des großen technischen Infrastruktursystems der Telekommunikation." In I. Braun/B. Joerges (eds.) *Technik ohne Grenzen* (forthcoming).
- La Porte, T. R. (ed.) 1991. *Responding to Large Technical Systems: Control or Anticipation*. Dordrecht/Boston/London: Kluwer Academic Publishers.
- Mayntz, R., Hughes, T. P. (eds.) 1988. *The Development of Large Technical Systems*. Frankfurt/New York: Campus
- Mayntz, R., Schneider, V. 1988. "The dynamics of system development in a comparative perspective: Interactive videotext in Germany, France and Britain". In Mayntz/Hughes 1988, 263-298.
- Pater, S., Raman, A., 1991, *Organhandel. Ersatzteile aus der Dritten Welt*. Göttingen: Lamuv Verlag.
- Pichlmayr, R., 1986. "Von der Immunsuppression zur Immunmodulation am Beispiel der Organtransplantationen". In Lüst, R. et al. (eds.) *Beobachtung, Experiment und Theorie in Naturwissenschaft und Medizin*. Verhandlungen der Gesellschaft Deutscher Naturforscher und Ärzte, 114. Versammlung, 13-16 September, 1986, in Munich, Munich: Wissenschaftliche Verlagsgesellschaft, 155-168.
- Pruitt, T., Barrett, W. 1991, "Corporate Virtual Workspace." In: M. Benedikt (ed.), *Cyber-space. First Steps*. Cambridge, Mass: MIT Press, 383-410.
- Rochlin, G., 1989. "Informal organisational networking as a crisis-avoidance strategy: US naval flight operations as a case study". In *Industrial Crisis Quarterly* 3, 159-176.
- Rochlin, G., La Porte, T., Roberts, K. 1987. "The Self-Designing High-Reliability Organisation: Aircraft Carrier Flight Operations at Sea". In *Naval War College Review*, Autumn 1987, 76-90.

- Schoeppe, W., 1989. "Organisation der Organentnahme und der Organtransplantation in Europa". In Deutsche Stiftung Organtransplantation (ed.), *Gesellschaft Gesundheit und Forschung*, Neu-Isenburg, 19-28.
- Sherman, B., P. Judkin, 1992, *Glimpses of Heaven--Visions of Hell. Virtuality and its Implications*. London: Hodder & Stoughton.
- Sotto, R., 1993, "The Virtual Organisation", Dept. of Business Administration, Stockholm University, PP1993, Stockholm.

LIST OF FIGURES AND THEIR SOURCES

- 1 Eurotransplant Foundation (eds.) (1988a), Newsletter 53, Leiden, p. 28.
- 2 Eurotransplant Foundation (eds.) (1988b), Annual Report 1987, Leiden, p. 17.
- 3 Eurotransplant Foundation (eds.) (1988b), Annual Report 1987, Leiden, p. 21.
- 4 Deutsche Stiftung Organtransplantation (eds.) (1990), *Organspenden - eine gemeinsame Aufgabe*. Neu-Isenburg and Eurotransplant Foundation (eds.) (1988a), Newsletter 53, Leiden, p. 13.
- 5 Eurotransplant Foundation (eds.) (1988a), Newsletter 53, Leiden, Appenda.
- 6 Eurotransplant Foundation (eds.) (1988a), Newsletter 53, Leiden, p. 12.
- 7 Eurotransplant Foundation (eds.) (1986), Manual, Leiden, p. 43, and Newsletter 53, 1988a, p. 7
- 8 *Der Spiegel* 34, 1989, p. 65
- 9 Eurotransplant Foundation (eds.) (1988b), Annual Report 1987, Leiden, p. 21.
- 10 Eurotransplant Foundation (eds.) (1988b), Annual Report 1987, Leiden, p. 34.
- 11 Eurotransplant Foundation (eds.) (1989a), Newsletter 66, Leiden, p. 23
- 12 Schoeppe, W. (1992), "Nierentransplantation. Gegenwärtiger Stand in der Bundesrepublik Deutschland", *Deutsches Ärzteblatt* 13, p. B-711.
- 13 Eurotransplant Foundation (eds.) (1989a), Newsletter 66, Leiden, p. 5, and Newsletter 61, p. 10f.
- 14 Braun, I (1991), *Geflügelte Saurier. Systeme zweiter Ordnung: ein Verflechtungsphänomen großer technischer Systeme*, WZB-paper FS II 91-501, Berlin: Wissenschaftszentrum Berlin für Sozialforschung, pp. 55-57.

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