Istanbul: A Successful Turnkey System

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For light rail transit (LRT) systems, turnkey procurement methods can offer cities more rapid construction, less risk, and assistance with financing the project. Turnkey arrangements are particularly useful for cities that lack an existing mass transit system with in-house expertise for developing LRT. Istanbul relied on the turnkey approach to construct a state-of-the-art, 24.2-km LRT system in two stages. The system was in operation within 30 months and a financing package was put together with the assistance of the governments of the countries involved in the project (Turkey, Sweden, and the United Kingdom) through the use of different export credit systems and by an international syndicate of some 16 banks. With the first stage of the system in operation, ridership has already reached 65,000 per day.

Before addressing the benefits of a turnkey system approach to light rail transit (LRT), some definitions are necessary. So-called turnkey deliveries can be on several levels, depending on how much responsibility the operator would like to put on the contractors. Still, turnkey means the supply of a system, or parts of the system, ready for operation.

One approach to turnkey systems is design/built. Design/built means that the operator or purchaser designs the system or parts of the system up to a certain point. After this initial design, contracts are awarded to one or several contractors who are responsible for the detailed design and supply. One of the contractors is also given the responsibility for the coordination of the total system.

Turnkey means that the operator or purchaser gives one contract to one contractor based upon a performance specification for the total system (i.e., more or less all the design work is carried out by the contractor). The contractor hands over the system ready for operation to the purchaser.

The contractor could also be responsible for arranging financing for the total supply. Financing could be made on commercial or more favorable mixed credit terms. This kind of arrangement is sometimes called super turnkey. When financing is not available and when, in particular, commercial credit must be raised for the construction of a system, it can be beneficial for the purchaser to combine the turnkey approach with a complete supplier-arranged finance package. The reason is that private institutions will favor taking a risk when one reputable major company takes on the turnkey responsibility. The credit risk is deemed smaller when the system becomes operational within a short time period.

Two other types of system supply definitions are in use: BOT (build, operate, transfer) and BOO (build, own, operate). In these cases the contractor has to take on both the design and construction of the total system, as well as the financing of the system. Financing in this case means that the contractor will take equity in the operating company and find commercial or mixed credit to support the rest of the construction. The contractor will also operate the system for a certain period of time, normally 10 to 15 years. Then the system will be transferred to the purchaser.

Most mass transit systems do not run at a profit, in particular when the financial costs are included in the calculation. Hence the BOT/BOO approach for this type of operation seems to be impossible unless construction companies can be given rights to exploit real estate. The real estate around stations and lines of a mass transit system normally increases in value. Part of that value increase could then be exploited by the civil contractor involved in the building of the mass transit system. It is however unclear how such a deal can be structured.

BOT and BOO put a heavy burden on the contractor and, as profits will not come from the operation, it is doubtful whether such systems will appear other than in rare cases. The same objectives can more or less be achieved by something one could call BTO (buy, transfer, operate). The total system is built by a contractor according to a performance specification. It is then transferred to the purchaser. The contractor is then awarded a contract for the operation, maintenance, and service of the system, including guarantees for its performance. In this case a contractor has all the responsibility to ensure that the system is designed properly and can be operated within certain cost limits. From the purchaser's point of view, a long-term contract covers the operation, but the purchaser has to pick up the difference between ticket revenue and operational/financial costs. This BTO principle should be feasible in many places where the transit authority lacks the experience to build and operate a system. This is a further development of a super turnkey operation and will further enhance the availability of credit institutions assuming the financial risk.

TRADITIONAL PROCUREMENT METHODS

The traditional method for constructing transit systems has been that the customer or operator spends years preparing detailed specifications for each subsystem. This is done by the customer organization or by hired consultants.

Very often the specifications are very detailed being more or less a design document. With this approach, the customer will take on the total integration responsibility (i.e., the responsibility of fitting all subsystems together). Any gray zones leading to missing equipment or unnecessary overlaps are with the customer.

This is why all specifications are very detailed. To involve several suppliers, the customer tries to open up the docu-

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ments; however, normally too many restrictions still remain. No supplier can fulfill all requirements with its standard products, which lead to redesigns and increased costs. Further new designs will produce problems during the start-up of the system. Once the specifications are ready, the customer calls for bids, selects interested bidders, and negotiates the contract.

As a result the customer is the total project manager and requires a strong customer organization with a lot of good experience. When building a system over a long period with several lines, this can be justified, as the project organization is continuously in operation over considerable time. After completing the project, this organization is redundant.

WHY TURNKEY?

Within the sphere of public transportation, turnkey procurement has not yet evolved as a major feature, although some contracts have been awarded, especially for fully automatic systems. The traditional contract route is to use separate packages for civil works, buildings, vehicles, and different electromechanical supplies, leaving the overall coordination with the customer or the customer's consultant. A typical public transportation turnkey project has two main portions, civil works and electromechanical works. The number of subsystems in the total concept will vary depending on the complexity of the mass transit system.

Systems will, however, become more and more complex. Advanced passenger information systems, both on board trains and at stations, require integrated solutions. Advanced automatic control systems make it possible to shorten the headways between trains safely. Trains can also be operated automatically without drivers. These new technologies call for a change in responsibilities. Automatic guided transit (AGT) systems call for a turnkey package as reliability, availability, and total safety must be integrated in the total system design.

Turnkey system engineering, employing one contractor with overall responsibility, results in effective coordination of the design process and produces synergies of implementation. Initial traffic studies, consultancy reports, and procurement procedures traditionally employed can all be streamlined.

Complete systems responsibility also ensures direct channels of communication, integrated systems planning, and a better scope for parallel activities in production and materials handling. Lead times are considerably shortened and the transit system will be put into revenue service earlier. The short implementation times of system design engineering reduce capital costs and allow the public to enjoy the benefits of an efficient city transport system much sooner. System design engineering is based on a common set of objectives agreed to by both customer and contractor. Systems responsibility is assumed for both the design and implementation phases of the project, which ensures that realistic and effective designs, products, and procedures are employed.

System design engineering gives a single contractor full responsibility for the delivery of a complete rail transit system. Deliveries of various hardware elements are coordinated and optimized through proven methods applied by an experienced contractor.

Turnkey supply means

- One contract with the technical performance defined, one single time schedule, and one price;
- No multiparty discussions; and
- The client's risk held at a minimum.

The performance requirements should state

- Plant and system objectives, such as availability and reliability;
- General descriptions, such as conceptual layouts, general design principles, and anticipated traffic flow; and
- Design requirements, such as quality and maintainability.

For the client to have the full control, appropriate milestones should be set in the contract, such as

- Submittal and approval of technical specifications (preliminary and final);
- Inspections and tests according to plan regarding essential equipment, subsystems, and the complete system; and
- Provisional training and final documentation relating to operation, overhaul, and maintenance.

The turnkey concept is most favorable when the following general conditions apply:

- The customer lacks the knowledge to perform the total project coordination, and the customer does not consider it cost-effective to develop this knowledge. This implies that the customer is most likely a new transit organization with no system in operation.
- Financing arrangements are more advantageous if a turnkey approach is used.
- The customer has an interest in minimizing the risks to the customer organization.

PROJECT ISTANBUL

The Istanbul LRT system is a successful example of a turnkey project. The customer, the greater city of Istanbul, awarded the total responsibility for the construction as well as for the finance package to one contractor.

Istanbul—A Living History Book

Istanbul is on the shores of the Bosphorus, a narrow strait between the Asian and the European continents. By controlling the Black Sea–Mediterranean and the east-west trade routes, the city has always flourished and because of its strategic position, the threat of being conquered has always been real.

According to tradition, the history of Istanbul started with Byzas, a wanderer from west of Athens. He founded the city as Byzantium around 650 B.C. In 330 A.D., the Roman emperor Constantine moved the seat of his empire from Rome and founded East Rome on the seven hills of this city as the new Christian capital—Constantinople.

In 1453 the Turkish sultan Mehmet II Fatih conquered the city, and it became the capital of the Turkish Ottoman Empire, which extended over a large part of southeast Europe and a major part of the Arab world for some 450 years. The last sultan abdicated in 1915.

The nation of Turkey has a very short history of democracy. A democratic constitution was formed for the first time under the presidency of Kemal Atatürk when he formed the Turkish republic in 1920. To defend the constitution, the military has an obligation to run the government if a major crisis is occurring.

The last takeover was in 1980 when total anarchy was ruling. General Kenen Evren took over the presidency and stayed in power until 1983, when national and local elections took place. ANAP, the Motherland party, won a majority in Parliament and most of the mayoralties. A government under Prime Minister Turgut Özal was formed. The Turkish economy then entered a period of very rapid growth and a large number of investment projects were begun.

Traffic Planning

The ancient city of Istanbul has the fastest population growth in Europe, increasing by some 1,000 per day, because of migration to the city and a rather high birth rate. The number of inhabitants is officially some 7 million, but unofficially figures of around 10 million are mentioned. The public transportation network, however, can barely cope with present demands, let alone those of the future. Sooner or later the situation would have become so severe in terms of both traffic and population that traffic would have come to a complete standstill.

In common with many other cities of the world, those in Istanbul responsible for traffic planning can hardly foresee the needs that such rapid growth brings. City authorities today are confronted with insuperable problems in finding day-to-day solutions for travelers of every kind. And time is continually against them.

The mayor of Istanbul, Mr. Dalan, who took office in the early 1980s, made a policy decision that within 5 years Istanbul's water supply and sewage systems would be improved, the sea would be free of pollution, traffic would be running smoothly, and the new infrastructure of the city would be complete.

Istanbul had a streetcar tramway system in operation until 1964, but like in many other cities the system was closed down, so that the only modes of traffic were buses, dolmuses (shared taxis) and minibuses, taxis and private cars, and commuter trains to the central stations of Haydarpasa (Asia) and Sirkeci (Europe).

Since the opening of the first Bosphorus Bridge in 1973, car traffic between the Asian and European sides has increased tremendously. The number of cars in Turkey for a long time doubled every 4 years, and most of these cars are located in Istanbul. Since the 1960s a discussion regarding an underground rail system, a metro for Istanbul, had been going on. A number of feasibility studies had been performed, but even though Istanbul has one of the oldest existing funiculars, the 500-m Golden Horn "Tunnel," no decision was made to start the construction of any further underground rail systems.

The city authorities had two alternatives. One was to develop road systems to cope with a dramatic increase in road traffic capacity and then to make extensive use of buses. For the current volume of traffic in Istanbul this would have meant several major motorways each 100 m wide, sweeping through this beautiful 2,500-year-old city. This solution was quite unacceptable.

The other alternative was a rail system.

In 1984, as in other cities around the world in a similar situation, proposals for the construction of an LRT system started to appear in Istanbul. It was soon realized that LRT had much to commend it, being cheaper and faster to construct than conventional metro or heavy rail, yet providing a permanent alternative to road transport.

Design/Build Turnkey Contract

By the end of 1984 the greater city of Istanbul had put together a performance specification based on a design/build turnkey contract scheme. Bids were invited, and best and final bids were received in mid-1985. Negotiations with the successful consortium were held during the autumn, and a contract was concluded, including final prices for civil works, which led to the signing of a letter of intent in December 1985.

In February and May 1986, contracts were completed for the construction of a 24.2-km LRT system in two stages from Yenikapi to Ataköy on the European side of Istanbul, south of the Golden Horn.

The successful ABB-Yapi Merkezi Consortium consisted of ABB Traction AB (formerly ASEA Traction) of Sweden as consortium leader and Yapi Merkezi Insaat ve Sanayii AS of Turkey, as civil works partner. ABB Traction is a member of the ABB, Asea Brown Boveri, Group. In addition to being the consortium leader, the company is responsible for all electrical and mechanical equipment, including the light rail vehicles (LRVs). ABB has been involved in the development and supply of electric railroad technology for the past 100 years and has worldwide experience in the power supply and railroad vehicle sectors.

Yapi Merkezi is one of the leading civil engineering and construction companies in Istanbul. The company is responsible for all building, civil construction, and track work. Yapi Merkezi has completed a number of major construction projects in Turkey, such as roads and bridges and the restoration of several historic buildings.

The contract is on a design/build turnkey basis, which means that in theory, but not in practice, the customer can place the contract, walk away, and come back later to take over the completed railway system. The customer has passed on to the contractor the responsibilities for coordination and the interface between individual contractors and professional consultants. However, the responsibility for operation, utilities diversion, expropriation, and clearance of sites remained with the customer. This type of contract was chosen because of the specific key benefits it offered:

- A reduced time schedule,
- Lower overall cost,
- A clear relationship: one client–one contractor,
- Clear responsibility for quality,
- Close integration of electrical, mechanical, and civil systems, and
- Unambiguous responsibility for performance.

The general conditions of the contract are the internationally well-known conditions of contract for works of civil construction from Fedération Internationale des Ingenieurs-Conseils (FIDIC).

Financing Contract

As a condition of the contract being awarded, the city insisted on an attractive financing package. ABB was able to finance the total sum of approximately $400 million (U.S.). This package was made possible by the support of governments of the countries involved in the project through the use of different export credit systems, and by an international syndicate of some 16 banks.

The financing covered all contractual works, both local and others. However, it had already been anticipated at this stage that additional financing might be necessary before the start of the second stage.

Istanbul LRT System

The initial contract, for 24.2 km of segregated double track, is divided into a first stage of 8.9 km and a second stage of 15.3 km. The civil works portion of the contract includes the design and construction of tunnels and viaducts; track and track bedding; a depot for 165 cars; a maintenance and overhaul building; a traffic control center; 19 passenger stations; power supply substation buildings; and service systems, such as cable, water, drainage, and sewer systems. The electrical and mechanical works include the design, supply, and installation of

- 105 complete LRVs—70 MD-cars with a driver's cab and 35 M-cars without driver's cab;
- Power supply consisting of transformer and rectifier substations, switchgear, and overhead catenary system, remote control (signaling control and data acquisition [SCADA] computer system), and cabling;
- Signaling and communication systems consisting of a microcomputer-based interlocking system, automatic train protection, centralized train control, radio communication, public address, and central clock; and
- Service systems consisting of functional design and equipment of the maintenance and overhaul workshop for 165 cars, lighting and power distribution, and heating and ventilation in the workshop.

In addition, the contract called for a comprehensive training program for the employees of the operation company; commissioning of the subsystems; and a complete system test.

Originally only minor tunnels and a number of viaducts were planned in the routing, but before the effective date of contract, 2.5 km of cut and cover tunnel was added. The tunnel stretches from Aksaray to Ulubatli in the downtown area, to a major extent following the main avenue, Vatan Caddesi. Three underground passenger stations are included. This was the result of a more extensive feasibility study during the last phase before work started.

The stations are designed to handle four-car trains although only three-car trains will be used initially. This will enable the system to be expanded without problem.

The vehicles are operated as three-car train sets with cabs in the outer cars. Each car is made up of two articulated sections and three bogies, with two of the bogies being powered and a trailing center bogie under the articulation. The electric motors are used for acceleration and regenerative braking of the train. The system ensures that the maximum amount of energy is returned to the power system.

The entire electrical system is fully microprocessor-controlled and includes a fault logger and an electronic display in the driver's cab to indicate the faults. The metro system is controlled by a state-of-the-art, microcomputer-based interlocking and safety system. Power is fed to the metro vehicles through a catenary system and is distributed from the main supply station to rectifier stations along the route.

The traffic control center is the heart of the metro operating systems and includes radio communication to the drivers, monitoring of the main line interlocking system, and power supply operation.

The Customer

The greater city of Istanbul was the main customer and the head of the technical department was appointed project manager, the engineer. A separate contract was signed with Istanbul Technical University (ITU) to act as technical consultant to the engineer.

The city's intention was to allow the Istanbul Bus Company to be responsible for the operation of the LRT system, but in 1988 a new company, Istanbul Transportation Company (ITC), was formed for this task.

Subcontracting and Consulting

For parts of the civil works, Yapi Merkezi subcontracted other design and construction companies, both Turkish and from abroad, but the design coordination and planning of these parts was handled by Yapi Merkezi themselves. For the track, the Swedish company GIA Industri was subcontracted. As a main consultant, involved in the civil engineering design of the first stage, the Turkish company United Engineers Group, BMB, was contracted.

ABB Traction handled the deliveries of the LRVs and the power supply system within its own organization. For the other electromechanical subsystems very reputable companies were contracted by ABB Traction, such as

- ABB Signal (former Ericsson Signalling Systems) of Sweden for the signaling and safety systems,
- Balfour Beatty of the United Kingdom for the overhead catenary,
- Brown & Root Vickers (former Vickers Design & Projects) of the United Kingdom for the workshop,
- Simmering Graz Pauker (SGP) of Austria for the car bodies, and
- Ascom Radiocom (former Autophon) of Switzerland for the radio communication.

The principal consultants called in for technical assistance during the execution of the first stage were Scandiaconsult of Sweden, MARConsult of Sweden, and Dogan Haritas of Turkey. Other companies involved in the project were Gothenburg Transit Authority of Sweden, Stockholm Metro of Sweden, London Transport International of the United Kingdom, and Birmingham University, also of the United Kingdom.

Success in Record Time

In March 1989, not more than 30 months after the effective date of contract, the first stage was inaugurated. A trial operation was initiated along with an extensive training period for ITC personnel on driving the cars, dispatching the traffic, and maintenance and overhaul.

Verification tests were performed in July and August of 1989 with the fully trained personnel. The final test included operation with 2.5-min. headways with crush load for 1 hour. The test results were overwhelmingly good and showed that the performance of the different subsystems, when working as one LRT system, was excellent. The results also indicated that ITC personnel were well-qualified to participate in the test, both from a driving and a dispatching point of view.

Because of political implications, a second inauguration was conducted in September the same year. Commercial operation was started from that date with an ever-increasing patronage.

Today

A number of complications with the second stage, even though they had been discussed since early summer 1988, became even more obvious with the start of commercial operation. The feasibility study and the final routing for the second stage had not been concluded. Additional financing, because of additions in the first stage, had become a necessity.

The political change in the mayoralty and the introduction of a new engineer on the city's side eliminated the possibility of a rapid solution and led to a 2-year moratorium.

The feasibility study for the second stage was completed in the beginning of 1991 and alters the routing to absorb many of the existing heavy routes of travel rather than developing routes in new areas of the city. The new routing goes from Otogar to Yeni Bosna, close to the airport. The distance is 9.7 km and includes 1.6 km of viaduct and 750 m of cut and cover tunnel. A financing package covering $100 million (U.S.) has been arranged and the work has now started.

The time frame for the second stage is 26 months. In the meantime, a temporary passenger station has been opened at the Ferhatpasa/Esenler depot and the number of passengers has increased to some 65,000 per day for the portion of the system in operation.

Sustainable Development for Istanbul

The design/build turnkey method of contracting allows traditional design, manufacturing, and construction timescales to be significantly reduced. In the Istanbul case it would also have been impossible to finance the local works if a turnkey contract had not been employed.

The turnkey contract made it possible to move from the original idea in 1984 to the start of the project in 1986 and then to the opening of the first stage as soon as 1989. The reduced timescales also allowed costs to be reduced.

The situation today is that the operational revenue covers operational costs and makes a contribution towards the paying off of the capital investment. If, however, the contribution to the national economy is considered, the LRT system

- Provides lower travel costs compared with cars, buses, etc.,
- Operates at a higher average speed than other modes, and
- Emits no exhaust fumes into heavily polluted areas of Istanbul.

Considering that the second stage will bring more densely populated areas within reach of the LRT, the future looks very bright.

The modern state-of-the-art system, which introduces LRVs with converters based on GTO thyristor techniques and a microcomputer-based interlocking signaling system to Turkey, is today operated and maintained by the Istanbul Transportation Company, without any support from the consortium. It is a success story both for the city of Istanbul and for Turkey as a nation.

To this sustainable development should be added the level of expertise achieved within the Istanbul Technical University and also within the civil works partner in the consortium, Yapi Merkezi. Additionally it can be noted that Yapi Merkezi has been the sole contractor for the construction of a 1.9-km heritage tram service along the Istiklal Caddesi in Istanbul, between Tunnel and Tksim, which opened in December 1990. Yapi Merkezi also has a contract for the laying of 3.7 km of track for a tramway from the Istanbul LRT passenger station Akşaray to the railway station Sirkeci. These two contracts would most probably not have been possible without the experience Yapi Merkezi gained on the LRT system.

CONCLUSION

The result of the turnkey approach is faster implementation, which leads to less cost because the capital is brought into operation earlier. The contractor can also use standard solutions, although the overall system performance specified must be met, which means lower costs in design and less risk with problems during start-up and so forth. By combining the turnkey approach with an operation and maintenance contract, the customer organization can further lower its risk and ensure that the system meets its long-term performance specifications both in terms of transport capacity and operational costs.

The Istanbul project verifies the benefits of the turnkey approach, including the financial part. The system was in operation within 30 months, and the complete financial package, including the extension, was arranged.