Abridgment

Project 21: A Practical New Intermediate-Capacity Rapid Transit System

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Project 21 is a rail transit system that incorporates most of the features of classical rail rapid transit but is optimized for elevated placement and for intermediate-capacity applications. An overview of the system is presented. The novelty of the system is concentrated in the slender guideway, car suspension, and a practical branch for two-way traffic. All of these, and the associated third-rail power distribution, have been refined in recent years and are considered ready for construction of a prototype. Commercial service in a 55-mile/h regional network could start in five years. The potential benefits are widespread use, extraordinary safety and reliability, quick installation, very low capital cost, and moderately low operating cost.

Project 21 is a new transit system for metropolitan areas that have identified the need for rail transit but are unable to obtain the necessary funds. In most respects, Project 21 is a form of rail rapid transit in that it provides

1. The energy efficiency and all-weather reliability of steel on steel;
2. The speed and operating efficiency of an exclusive guideway, level boarding, and prepaid fares;
3. The environmental and reliability advantages of electric power;
4. A switch generally like a railroad switch;
5. Cars that can run individually or be coupled into trains; and
6. A guideway suitable for two-way traffic with occasional grade-separated branches.

To provide these features at greatly reduced cost, Project 21 departs from classical rail rapid transit in these respects:

1. It is scaled for capacity in the range of 10 000 to 20 000 passengers/h.
2. It is specially adapted for elevated placement to avoid the huge cost of tunnels.
3. It has radically reduced guideway dimensions to make the elevated line acceptable along streets and boulevards in sensitive areas.
4. Station dimensions are also radically reduced.
5. It has a unique branch arrangement, compact enough for placement above the streets.
6. It features standardized and modular guideway, stations, and branch elements to permit factory production, quick installation, and flexibility for the future.

The system also has other assets in terms of rider appeal and safety that will be discussed in this paper.

BACKGROUND

Project 21 arose out of my search for a practical, intermediate-capacity transit system, beginning in the mid-1960s. Active work on this system began in 1971 with the discovery of a practical means for branching of elevated two-way traffic. Early refinement of the concept was done by a team at Lockheed. The guideway design was further refined in collaboration with Lloyd H. Donnell, the American Bridge Division of U.S. Steel, and a major supplier of electrical distribution hardware. Specific applications were worked out for a network in Los Angeles and a smaller layout at the Los Angeles International Airport. The system is proprietary, being covered by U.S. patents 3,890,904 and 253,750.

GENERAL SYSTEM ARRANGEMENT

The cornerstone of the Project 21 system is the novel guideway arrangement, which uses a triangular section that carries the transit cars on each side, as shown in Figure 1. Support and guidance for the cars are supplied by means of a slightly modified standard rail fastened at the lower corner of the steel beam. This rail also takes all traction and braking forces and serves as the electrical ground. To prevent cars from tipping away from the beam, there is a unique upper rail, which is integral with the apex of the beam. The power-supply "third rail" is beneath, and protected by, this upper rail.

CARS

Cars for the system are about the size of a small city bus and have seats for 22 passengers and standing room for about 20 more (crush load). The "lead car" has provision for an operator using conventional controls. This car can operate alone in off-peak hours and is supplemented by "B cars" in rush hours. Trains could be any length desired, but the current system definition calls for a maximum of four-car trains in order to limit the length and cost of stations. Figure 2 shows the general arrangement of the lead car. As indicated in Figure 3, the B car is similar except that it has a passageway in front and no operator position.

The inboard side of the car is shown in Figure 4. It has folding double doors for entrance and exit at the station and two windows. The trucks are located in recesses near the car ends and are removable from outside. Each truck comprises a 600-V motor, gear drive, brake, and a single, steel-rimmed wheel. The truck also has integral hooks to surround the lower railhead and thus prevent derailment; the wheels are barely visible beyond these hooks.

Figure 5 shows a section through a car in the seat area. The width of the forward-facing double seats is typical for rail rapid transit; the same is true of the aisle width and headroom.

CAR-TO-GUIDEWAY INTERFACE

The placement of the truck in the car and its relation to the beam are shown in Figure 6. The wheel rim is concave, to form a double flange for precise centering. There is a suspension linkage between truck and car with a suspension unit as shown. There is no need for the one-wheel truck to swivel in curves; this greatly simplifies the suspension.

Above each truck there is an "outrigger" that takes tension loads to prevent overturning of the car. This outrigger engages the upper rail by means of a set of rollers, four above and four below the rail's horizontal web. The rollers are mounted in a steel frame that surrounds the upper railhead; this ensures positive grip even if the rollers themselves

Figure 1. General view of Project 21 system.

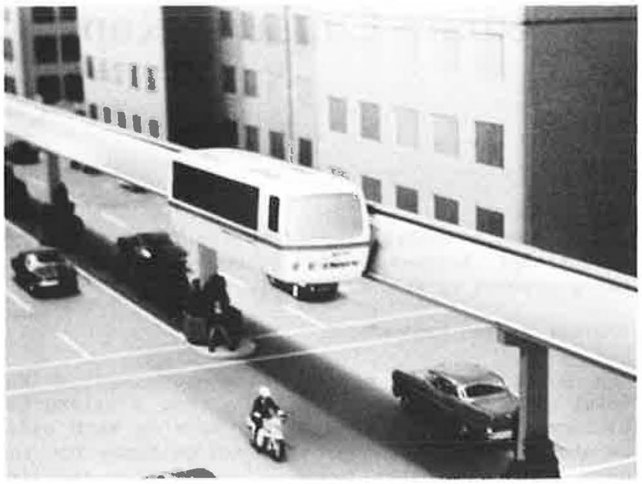


Figure 2. Cutaway view of lead car.

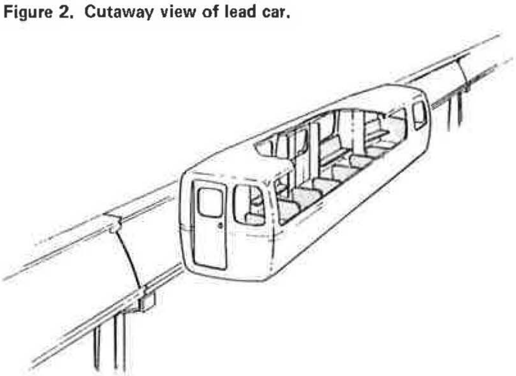


Figure 3. Floor plan of B car.

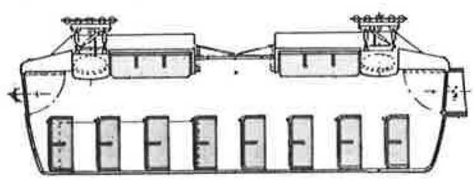


Figure 4. Inboard side of car: trucks, doors, and raised outriggers.

should fail. The same frame also mounts the power collection shoe.

Figure 7 shows details at the apex of the beam. In addition to the two top rails and associated third rails, it shows one outrigger frame and its rollers. Also shown are the massive main power conductor, securely enclosed inside the beam structure, and a "snow guard" to protect the roller path. These details have been carefully worked out to ensure excellent all-weather reliability.

Figure 5. Section through car in seat area.

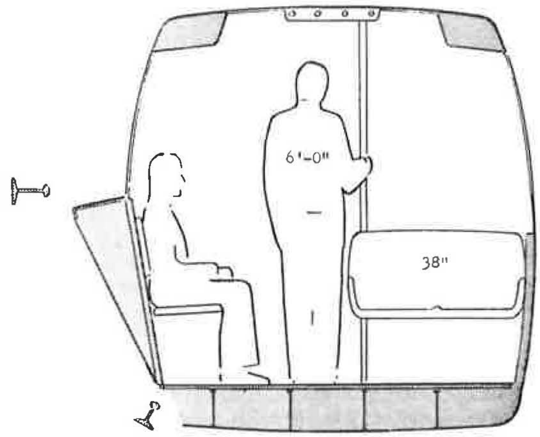
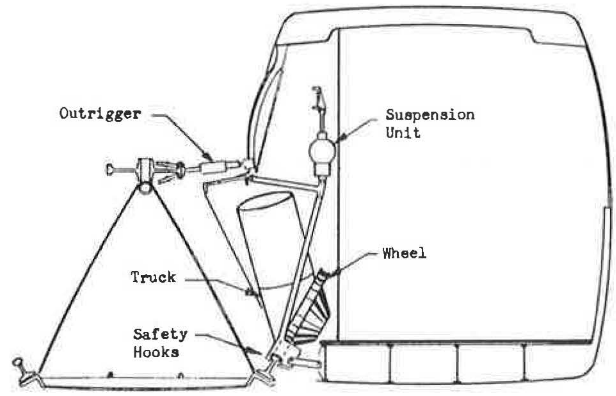


Figure 6. Section through car and beam at wheel.



STATIONS

Stations are placed between the two tracks, which curve apart as the station is approached (see Figure 8). The waiting area is fully enclosed for environmental comfort as well as safety. The floor is level with the car, and there are generous biparting doors for access to the train. Four sets of doors on each side of the station allow trains up to four cars long.

Vertical access is by two stairways plus a large elevator, as shown in Figure 9. A 10-ft median in the street is sufficient for ground-level circulation, protective fences, and station supports.

The upper rail of the "track" alongside the station is placed above the passenger's head (Figure 9). This requires the car's outriggers to rise, at stations, to the position shown in Figure 4. The guideway transition shown in Figure 8 provides for this change in upper-rail position while keeping the cars perfectly level.

BRANCHES

The key to the Project 21 branch is a pair of back-to-back switches, each inclined to match its adjoining track. Figure 10 shows how a two-track branch line departs from a two-way trunk line. The trunk line bulges locally to blend with the switches; maximum width in this bulge is less than

Figure 7. Section at top of beam.

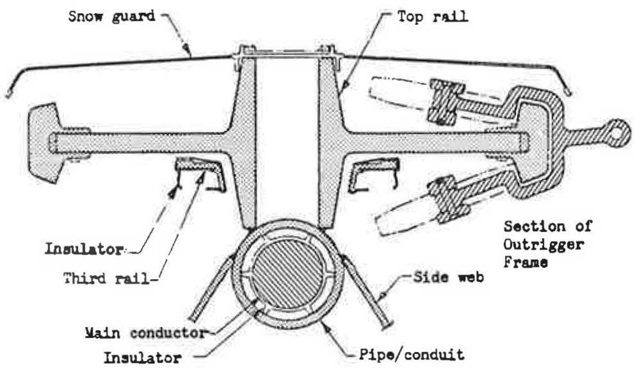


Figure 8. Basic station.

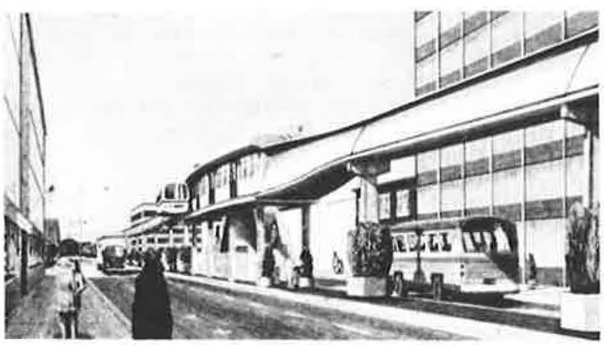
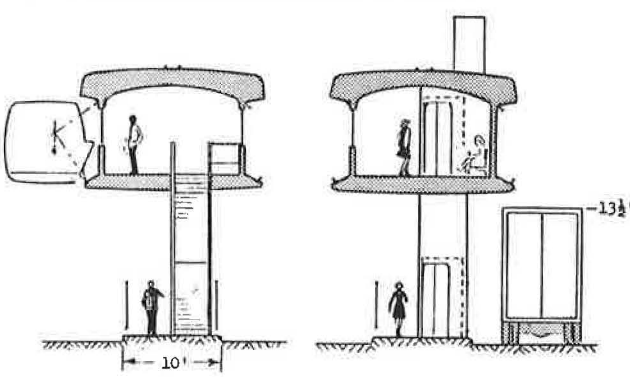


Figure 9. Sections through station at stairway and elevator.



13 ft. Figure 10 shows the design as of 1976; it has since been refined for fewer columns and gentler curves, as shown in Figure 11. This allows trains to pass through at 35 miles/h on the main line.

OPERATIONS

The cars can be controlled like trolley cars, relying heavily on the operator's vision and judgment. Other control modes, including the more sophisticated Metro-type systems, can be supplied at greater expense.

Running speeds, acceleration and deceleration, and station dwell times are similar to those for today's rail rapid transit. We favor station spacing on the order of 0.33 to 0.5 mile in urbanized areas so that most passengers can walk to and from a station. Although this penalizes line-haul speed some-

Figure 10. Branch design of 1976.

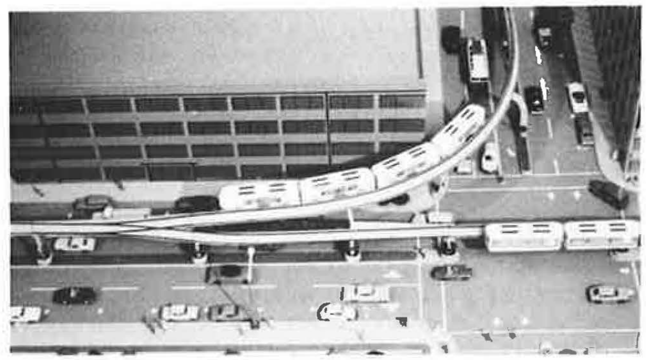
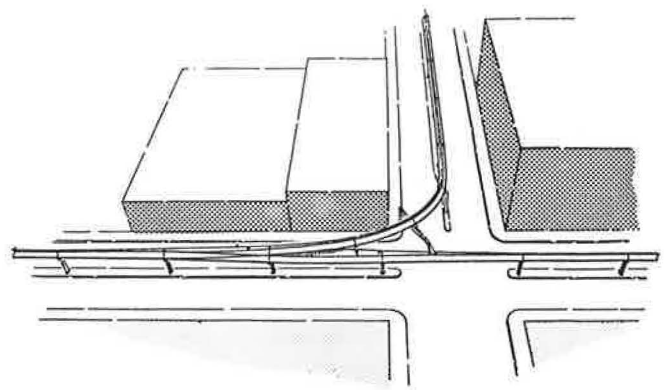


Figure 11. Computer drawing of refined branch design.



what, experience in many cities teaches that it is popular with the passengers and yields high ridership. It also avoids the need for extensive feeder systems and large parking lots.

Maximum speed for the initial design is 55 miles/h, more than enough for the station spacing just discussed. Higher speeds (for airport connections and other longer-distance applications) may be available shortly after experience is gained with guideway alignment and outrigger bearing life.

Headways, governed by arrival and departure at the stations, can be as short as 50 s under operator control. On this basis, line capacity is 11 000 passengers/h/direction, matching the greatest demand of cities like Boston and Philadelphia. Off-line stations have been designed to permit express trains for longer trips. This increases system speed and efficiency; more important, it increases capacity to about 19 000 passengers/h/direction, which equals the actual ridership of all U.S. cities except New York.

The system design provides several means of emergency escape, convenient maintenance inside the hollow guideway and branch modules, and exceptional all-weather features, all of which have been reviewed with engineers in a dozen cities. Space does not permit them to be detailed here.

COST

There are indications that Project 21 will afford dramatic capital savings compared with other grade-separated transit. First, it avoids the enormous cost of tunnels. Furthermore, the guideway requires only 1200 tons of steel per mile, only one-third as much as the leading people-mover. Finally, there are the benefits of quantity production of standardized modules and minimum field work for erection and start-up.

American Bridge Division estimated the cost of the guideway at slightly more than $3 million/mile for a Project 21 network in Los Angeles. That was in 1975, and inflation would tend to increase the figure substantially. On the other hand, a number of major refinements suggested by American Bridge have now been incorporated. Today's cost may not be appreciably higher.

In comparison with other systems, the operating cost of the Project 21 system should be

1. Not as good as the few rail rapid transit systems that have one-man crews and no staff in the stations,
2. About on a par with rail rapid transit systems that have two-man crews and two to three staff persons per station, and
3. Much better than buses due to the larger train capacity (170 passengers) and considerably higher effective speed.

DEVELOPMENT

After 10 years of refinement, Project 21 is ready for the initiation of prototypes. The guideway is thoroughly designed and has been analyzed for fatigue, winds, earthquakes, and other conditions. Main details of the power distribution, car suspension, branch/switch, and station-to-guideway interface have been worked out and documented.

The contemplated development program will include quarter-scale validation mockups in the first year, half-scale running tests in two years, and first full-scale tests in three years. Commercial use at 35 miles/h should commence in four years. A regional network at 55 miles/h is attainable in five years, the time it usually takes to dig one major tunnel.

ACKNOWLEDGMENT

This is an abridgment of a 40-page professional paper that contains many more details about the Project 21 system, its rationale, and its pedigree. The full paper is available from Transit Innovations.

I am indebted to two corporations and a score of professionals whose participation and constructive criticism have been invaluable in bringing Project 21 to its present status. Among the individuals who provided assistance are the following: Sol Bucksbaum and others of American Bridge Division, U.S. Steel (guideway design, producibility, and cost); James Corl and others of Insul-8 Corporation (power distribution, third rail, and collector); Lloyd H. Donnell, American Society of Mechanical Engineers, Inc.(guideway design and analysis); and Boris Pushkarev, Regional Plan Association (the urban planner's perspective).

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Abridgment

Organizing for Effective Rail System Planning and Implementation: The Metro-Dade Experience

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The transportation planning and implementation structure of Metropolitan Dade County, Florida (the Miami urbanized area), is described, and key characteristics that make it effective are discussed. Four unusual aspects of organization for effective planning and implementation of major transportation improvements combine to form a unique decision-making process. Metropolitan government permits Metro-Dade to plan and implement transportation projects and obtain local concurrences with a minimum of delay. A detailed Comprehensive Development Master Plan for staged development is unusually precise in locating major transportation improvements and has been adopted by ordinance, which gives it the force of law. The voting membership of the metropolitan planning organization (MPO) governing board is the same group of elected officials that form the Board of County Commissioners, Metro-Dade's governing body. A staff function of the county manager's office—the Office of Transportation Administration—has authority over the planning, coordination, implementation, and/or regulation of all modes of surface transportation in the county and directs the operation of public systems including Metrobus, Metrorail, the Downtown People Mover (DPM), and special transportation services. In addition, it provides the technical and professional staff for the MPO. This unique organizational structure makes it possible for Metro-Dade to build its 20.5-mile, 20-station stage 1 Metrorail system on a planning-to-opening schedule of less than 10 years and to coordinate it with all other modes. Construction of a 1.9-mile, 10-station DPM and doubling of the Metrobus fleet to 1000 vehicles will be completed to coincide with Metrorail's opening.

In 1973, Metropolitan Dade County (Metro-Dade) contracted with Kaiser Engineers to prepare a preliminary engineering study for a rail rapid transit system to serve the Miami urbanized area. By early 1975, the plan was ready for acceptance by the county, and implementation was authorized. Construction of stage 1 of the project--a 20.5-mile, 20-station heavy rail line--was initiated in 1977, and by mid-1984 the $900 million system will be operating, only nine years after plan adoption.

Complementing the new Metrorail system at its opening will be two other major transit improvements: a 10-station, 1.9-mile downtown people mover (DPM) loop connecting with Metrorail at its downtown Government Center station and a 1000-vehicle Metrobus system, double its present size, that provides express, limited, Metrorail feeder, and local services.

But the most significant achievement of all has been the creation of an institutional structure that makes it possible for Metro-Dade's transit improvement program to be carried out with maximum coordination of its three major elements while keeping delays to a minimum. Lacking this institutional structure, planning-to-opening of Metrorail and the DPM and coordination of all other surface transportation modes could not be accomplished in less than 10 years if, indeed, it could be achieved at all.