Chapter VIII

OPTIONS FOR AUTOMATED GUIDEWAY TRANSIT RESEARCH AND DEVELOPMENT

Innovation in automated guideway transit (AGT) development can be stimulated by the Federal Government either at the supply or the demand sides of the market. Stimulation of the market at the current time is premature due to the state of technology development.

Four alternative supply-side strategies [illegible] to the development of production-ready advanced AGT systems [illegible] in this chapter. They tradeoff the advantages of a go-slow approach [illegible] allows for the market testing of less sophisticated technical systems [illegible] the potential benefits of proceeding more directly to full-scale prototype development.

Introduction

The Federal Government can bring about advances in AGT technology by supporting efforts to improve existing technologies or by guaranteeing eventual procurements to motivate technical discoveries.

The approach of market guarantees raises a range of issues touched on in several of the reports cited in chapter VI. In particular, OTA's report on industrial innovation stated:

> Most Federal programs intended to affect technological innovation have historically been concerned with the supply of new technologies. Accordingly, they have attempted to increase this supply by, for example, reducing the cost of development, undertaking research in publicly supported laboratories, increasing the rewards of innovation, etc. This policy emphasis has resulted in part from a widely held, but overly simple, view of the innovation process which sees R&D as the overridingly important aspect. In contrast, recent research emphasizes the complex interconnectedness of various stages in the innovation process and recognizes that market demands are often a more important motivator of innovation than technical discoveries.
>
> Evidence suggests that policies which work through influences on demand may often be more effective than those which concentrate on increasing supply. One way of influencing demand is by Government procurement. Evidence presented earlier in the report shows that an assured Government market for new products can be an effective stimulus co innovation. This conclusion is strongly supported by the foreign experience.

The downtown people mover (DPM) program sought to provide that assured market, but the apparent withdrawal of Cleveland, St.

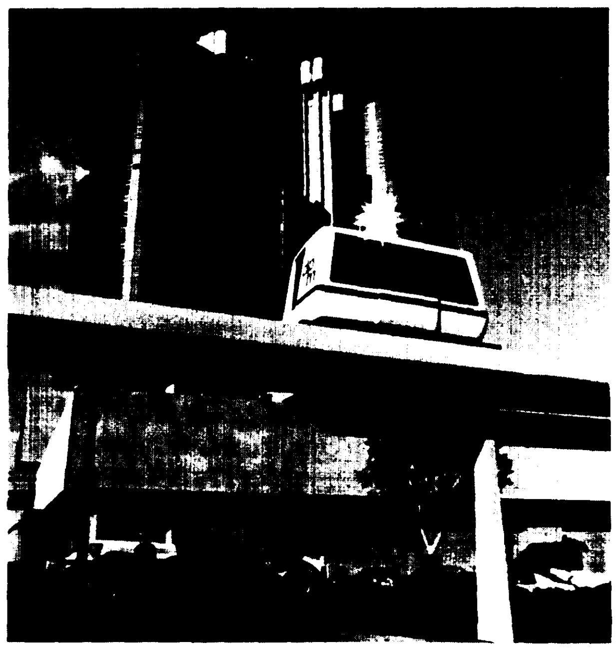

Photo credit Of Is Elevator

Downtown People Movers being planned in several U.S. cities

[1] U.S. Congress, Office of Technology Assessment, *Government Involvement in the Innovation Process*, OTA-R-73 (Washington, D.C.: U.S. Government Printing Office, August 1978), p. 66.

Paul, and Houston from the program demonstrates how difficult it is to guarantee a market. Even when the Urban Mass Transportation Administration (UMTA) offers to pay 80 percent of the capital cost there is no assurance that cities will cooperate, if they conclude the risks outweigh the benefits. The cities must be convinced that new technologies will help solve significant transportation problems at reasonable cost. There is growing doubt at the local level that federally sponsored transit R&D will provide workable solutions at an affordable cost.

Program Options for Advanced Technology Development

This section describes four specific supply side options that would lead to the availability of advanced automated guideway technologies in the late 1980's. The first two options would focus on laboratory improvements. The latter two would proceed to test track settings for validation of the existing advanced group rapid transit (AGRT) technology as an integrated system.

Option 1: Emphasize the Upgrading of Existing Technologies

The first objective of this option is to upgrade existing AGT technologies to the point where they will be able to provide viable urban transit service. None of the existing AGT systems have been subjected to the rigors and high expectations of the urban travel market. They are operating in much more benign environments—amusement parks, shopping centers, and airports. To become more viable options for urban development, they need improvements in reliability, durability, speed, capacity, security, and cold weather availability. The lack of a stable market for urban automated guideway technology precludes existing suppliers from upgrading their own technologies for such a market. At the present time UMTA is supporting a limited amount of such development with four system suppliers.

The second objective of this option would be to put improved systems into service as early as possible. For example, these technologies, as improved, could be used in the DPM demonstrations, or existing AGT installations could be retrofitted. This approach will provide more near-term results than the more advanced technology options that will not be production ready following current schedules before the late 1980's at the earliest.

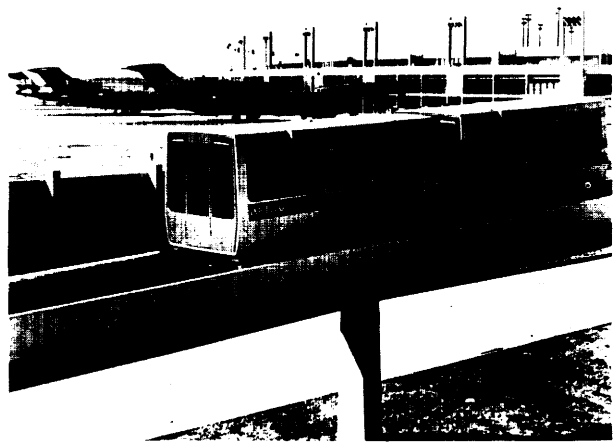

Photo credit L TVAC PR&A

Near-term option—upgrade airport systems for use in cities

The third objective of this approach, if pursued to the exclusion of other options, is to delay work on advanced technologies until many of the unresolved issues identified in chapter V (see table 4) are further analyzed.

Table 4.–issues Requiring Further Analysis*

- Guldeway and station congestion Impacts
- Consumer reaction to advanced automated guideway systems
- Methods to provide security in unattended vehicles
- Emergency evacuation procedures
- Effects on land use development patterns
- Relationship to other Federal programs and policles
- Acceptability of the esthetic Impacts of elevated guldeways
- Impacts of snow accumulation and options for solutlon
- Optimum vehicle size and speed for energy efficiency
- Attainabllity of AGRT operating and maintenance cost goals
- Optimum guldeway shape
- Optimum vehicle and operating procedures for various appilcatlons
- Size and nature of required labor force
- Potential reduction In jobs for unskilled persons
- Impact of existing labor agreements

'This list is a summary of the unresolved issues listed at the end 01 each of the sections m ch V
SOURCE Off Ice of Technology Assessment

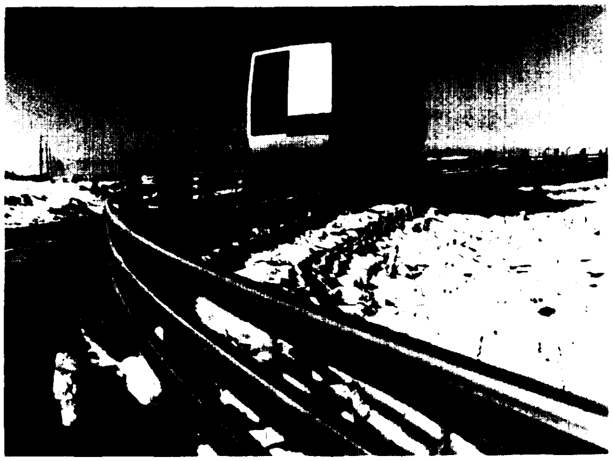

Photo credit Otis Elevator

AGRT must be able to operate in ice and snow

Option 2:
Emphasize Critical Subsystems Development

The Federal Government would support activities related to the development of subsystems or components that comprise the new technologies in AGRT (see table 5). The eventual goal of this form of the program would be to combine these subsystems into a working system (or family of systems). This program would then differ from UMTA's automated guideway transit technology (AGTT) program which is working on more general problems such as safety and security and cold weather reliability. As with Option 1, the results of this program as they come online could also be applied to existing new systems. In some cases they could also be applied to conventional bus and rail as well as to automated technologies. Decisions on the final shape(s) of AGRT would be deferred.

A shortcoming of this approach is that a realistic systems environment is needed to verify integrated component operations.

Table 5.–Typical Features of Advanced AGT Systems

• Linear induction motors	• Automatic training
• Air-cushion suspension	• High-speed swltchlng
. Magnetic levitatlon	c Goods handllng
• Mowng-block controls	• All-weather operation
• Colllslon avoidance radar	• Safety and security systems
c Minimum guldeway cross-section	Emergency braking

SOURCE Off Ice 01 Technology Assessment

Option 3:
Validate Subsystems in a Systems Environment

This option would provide the realistic systems environment necessary to test the interacting relationships of components but defer the additional costs of full-scale prototype development. A sample test configuration would include a small number of breadboard vehicles, a modest amount of guideway, and perhaps two or three switches. The validation program would be designed: 1) to verify that the tested components perform as expected (command and control, vehicle operations) and 2) to produce reliable cost estimates for decisions on further program direction.

Option 4:
Develop and Validate Technology on Prototype Systems

Complete prototype systems would be developed for one, two, or three of the technologies and engineering validation completed yielding production-ready systems. The prototypes would adhere to the UMTA AGRT specifications, although actual urban deployments need not adhere in all respects to the same design. As an example, a complete prototype validation would include multiple vehicles and sufficient guideway to test high-speed operation and switching. This testing would verify such functions as merging, longitudinal control, headway maintenance, and collision avoidance. Those functions that cannot be verified on the test track would be simulated in the laboratory, using computer analysis as required. UMTA has estimated this process as taking about 60 months.

The advantages and disadvantages of these four options are summarized in table 6. These options are not necessarily mutually exclusive. Option I could be carried out along with any of the other three. And OTA does not imply that there are clear-cut distinctions between Options 2, 3, and 4. In fact, there is a natural evolutionary process. The real distinctions among the options are in the amount of commitment that Congress wishes to make at this time given budget considerations and the need for further information.

Table 6.–R&D Options for Achieving AGT Technologies–Pros and Cons

Option	Pros	Cons
1. Emphasize the upgrading of existing AGT technology (Ie., DPM)	• Much to offer from existing AGTs, • Improves marketability of exlstlng AGTs, • Lowest level of technological risk • Allows time for other studies, • Defers major technological commitments, • Benefits many suppliers and technologies. • Incremental Innovation widely supported, • Does not outpace market for urban AGTs. • Least costly in short run.	• Slowest option for achieving deployable advanced technologies. • Yields modest AGT technology and service improvements. • Risk of Boeing and Otis leaving program. • Increasing technology gap with foreign systems.
2. Emphasize critical subsystems development	• New subsystems immediately deployable, c Low technological risk, • Allows time for other studies. • Defers major technological commitments, • Benefits other suppllers, • Supports Incremental Innovation. • Low short-run costs, • Can also Include Option 1,	• Slow option for achieving deployable technologies. • Major subsystems require a systems environment for engineering verlflcatlon • Risk of Boeing and Otis leawng program,
3 Validate subsystems in a systems environment	• Avoids costs of full prototypes. • Provides a realistlc environment for subsystems verlflcatlon • Provides cost estimates. • Malntalns supplier interest (Boeing and Otis), • Includes Option 2, can Include Option 1.	• Involves a technological commitment, • Forecloses other technologies,
4. Develop and validate technology on prototype systems	• Fastest option to achieve program goals. • Maintains continuity and stability of program, • Maintains suppller interest (Boeing and Otis), • Includes Optlons 2 and 3; can Include Optlon 1. • Reduces technology gap with foreign systems	• Highest technological risk, • Forecloses other technologies, • Marketabdity unsure, • Highest cost In short run.

SOURCE OTA staff analysıs

Number of Prototypes

Competition would create incentives to encourage economy and austerity in both system design and development and satisfy local requirements for competitive bidding.

Money spent on the development of alternative systems can be relatively inexpensive insurance against the possibility of picking an inferior alter= native.

A subsidiary question related to Options 3 and 4 concerns the number of prototype systems to be funded at this time should either of these options be selected. The OTA findings in this regard are derived from the conceptual stance outlined in chapter 111 that AGRT is but one potential configuration within a multidimensional option space. Other developmental programs within UMTA are more broadly based. The AGTT program, for example, is working on a number of problems (i. e., safety and security, cold-weather operation, guideway configuration) with wide applicability to automated systems, both existing and advanced. The DPM program, designed to demonstrate off-the-shelf automated guideway technologies, is open to a wide variety of offerings including various size vehicles, monorails, and suspended technologies.

Evaluation of R&D program options should consider the recommendations of the Commission on Government Procurement and the guidelines on procurement subsequently issued by the Office of Management and Budget as spelled out in Circular A-109. The essence of this policy is to maintain competition between similar or differing designs as long as maintenance of such competition is economically feasible. Some of the principal arguments in favor of retaining competition are listed in table 7.

There is a substantial degree of technological diversity offered by the three AGRT system concepts, particularly with respect to command and control, suspension, and propulsion systems. The cost of preserving these options, at least through the technology verification stage, is small in comparison with the cost of a single deployment. The retention of multiple suppliers is also consistent with Federal and local procurement requirements which favor a competitive bidding process. Critics of this approach claim UMTA is paying twice to solve the same mission and that ‘other missions or other appreaches to the urban transit dilemma should also be considered.

Table 7.–Principal Arguments in Favor of Retaining Competition

Arguments In favor of competition	Tradttlonal procurement process	Competltwe acquisition process
Provides flexibility for dealing with technological uncertainty	There IS no hedge against tallure	Money spent on the development of alternative systems can be relatively inexpensive Insurance against the posslbllty that a premature choice of one approach may later prove to be a poor and costly one
Allows for greater Innovation	Since Government has made the design declslons about the best approach to meet a need, private sector contractors compete for the development and production of a ' 'required system' and do not offer their own best solutions at thew lowest costs. Consequently, there IS llmlted opportunity for contractor Innovation and technical competition, contractors find it easier to promise the customer what he wants, rather than to Innovate and demonstrate new products	
	Large firms tend to acquire a technical base based on their experience with successful products and their customers' tastes Although smaller firms are likely to have more mltlatwe and to be more Innovative, they are usually discouraged from competing because the competition begins late In the process, when the costs are highest	
Provides for greater control over costs	With only a single organized effort underway to meet a need, system performance and scheduling sllppages have to be accommodated by additional funding. As a result of this monopoly sltuatlon, costly and burdensome controls and regulations must be applled to a greater extent than In competitive procurement to prowde public accountability.	Competltlon would reinstate a challenge to Industry to use a wider span of technologies for system solutions that are of lower cost and simpler design Competition would create Incentwes to encourage economy and austerity In both system design and development
Allows for performance as as well as price comparisons	There are no standards to measure the efficiency of a single undertaking and no competition to ald In choosing the best system. Source selections have depended less on technical differences between proposals and more on contractor predicted costs at a time of great technical uncertainty about the chosen system In relying on these cost predictions for Inltlal system procurement, Insufficlent weight has been given to system performance and to the costs that are eventually to be paid for operating, supporting, and maintaining the system	Competitve exploration of technical approaches should produce dlstlngulshably different system performance characteristics Technical differences would then become more Important crlterla for choosing systems and contractors than In the past when differences mainly Involved design detail and an uncertain cost

SOURCE *Report of the Commission on* Government *Procurement* vol 2 1972

Magnetic Levitation Technology

At this early stage in the development cycle there is no sound technical basis for discontinuing work or providing any promising technology with significantly less funding. Magnetic levitation is a particularly promising option because of its low noise and high reliability potential.

The suspended Romag technology (see figure 3), originally developed by Rohr, and licensed to Boeing in 1978, has several features of particular merit:

- it is believed more suitable for winter operations;
- the guideway shape is closer to a structural optimum, reducing costs and guideway obtrusiveness; and
- through the use of 1inear induction motors and magnetic levitation, the propulsion and suspension systems have no moving parts and hence, more reliable operating characteristics.

Although its development is currently receiving less funding than the other two AGRT technologies, Romag exhibits highly desirable characteristics as an alternative.

Funding

The program proposed by the Department of Transportation in early 1978 raised the total cost of the AGRT development program to $111 million (see table 2) which included the estimated effect of inflation through to an anticipated completion date in early 1984. This plan would spend $40 million each on the Boeing (wheeled) and Otis (air cushion) technologies with $5 million being devoted to Romag. This level of effort corresponds to Option 4. According to data from UMTA, $14 million of the $111 million had been spent through April 1979.

Early in 1979 UMTA scaled down these plans, Contracts recently negotiated with Boeing and Otis provide approximately $25 million to each contractor for further work on the wheeled-vehicle and air-cushioned systems. Boeing will also receive $9 million to continue development of magnetic levitation technology. Cost of the revised plan including prior expenditures totals $73 million. A decision to develop production prototypes has been deferred.

Possible funding levels for Options 1, 2, or 3 (table 8) acknowledge that the optimum development course to advanced AGT systems is not clear at this time and that technological options should be kept open as long as possible. Using a recent grant to upgrade Airtrans as a guide, the first option could entail costs of up to $5 million to $7 million per technology. As a guide to costs

Table 8.–Estimated Funding Levels for Advanced AGT Options

Optlon	Near-term program cost (millions)
1 Emphasize upgrad!ng of exlstlng AGT technology	$15-30”
2 Emphasize crltlcal subsystems development	$20-40”
3 Validate subsystems In a system environment	$60-80”
4, Develop and valldate technology on prototype systems (UMTAFY 1979 proposal)	$97

“OTA siafl estimates
SOURCE Olfice of technology Assessment

for Option 2, UMTA proposes to spend $13 million on engineering alone for the Boeing (wheeled) and Otis (air cushion) technologies, were complete prototypes to be planned for at this time (table 3). Additional manufacturers could be included adding to costs or some synergism introduced among the AGRT technologies to reduce costs.

Creation of a limited systems environment (Option 3) would have to include most of the full-system engineering costs, but only a portion of the fabrication costs. Savings could thus amount to up to $8 million to $10 million per technology. Assuming the two Boeing technologies would use a common command and control system, the requirements for Option 3 would be on the order of $60 million to $80 million.

Table 8 shows $97 million as the cost-to-complete of Option 4, based on the current plan of two full prototypes, and about $5 million for Romag. It is possible, however, to reduce the amount of prototype guideway and structures for system validation so that additional resources could be diverted to accelerate the development of magnetic levitation technology.

Goods Movement

A study should be undertaken to determine the extent to which automated systems could be used to transport some kinds of goods in urban areas, thus reducing road congestion and spreading the cost of automated guideway system construction.

Joint use of transportation facilities to move both people and goods is a historic practice, permitting the required capital investment to be spread over a greater number of users. The predominance of trucks for urban goods movement is a result of the ubiquity of the highway system, the ability of users to operate trucks sized to their specific needs, and the control of the industry over the timing of shipments.

The possibility that an automated system could be used for shipment t~f a substantial portion of goods in urban areas deserves consideration. Not all commodities could realistically be served. The most likely applications would be for goods moving in large volume to or from common supply or collection points such as mail or waste. Retail outlets might be included if enough of them are close enough to guideways

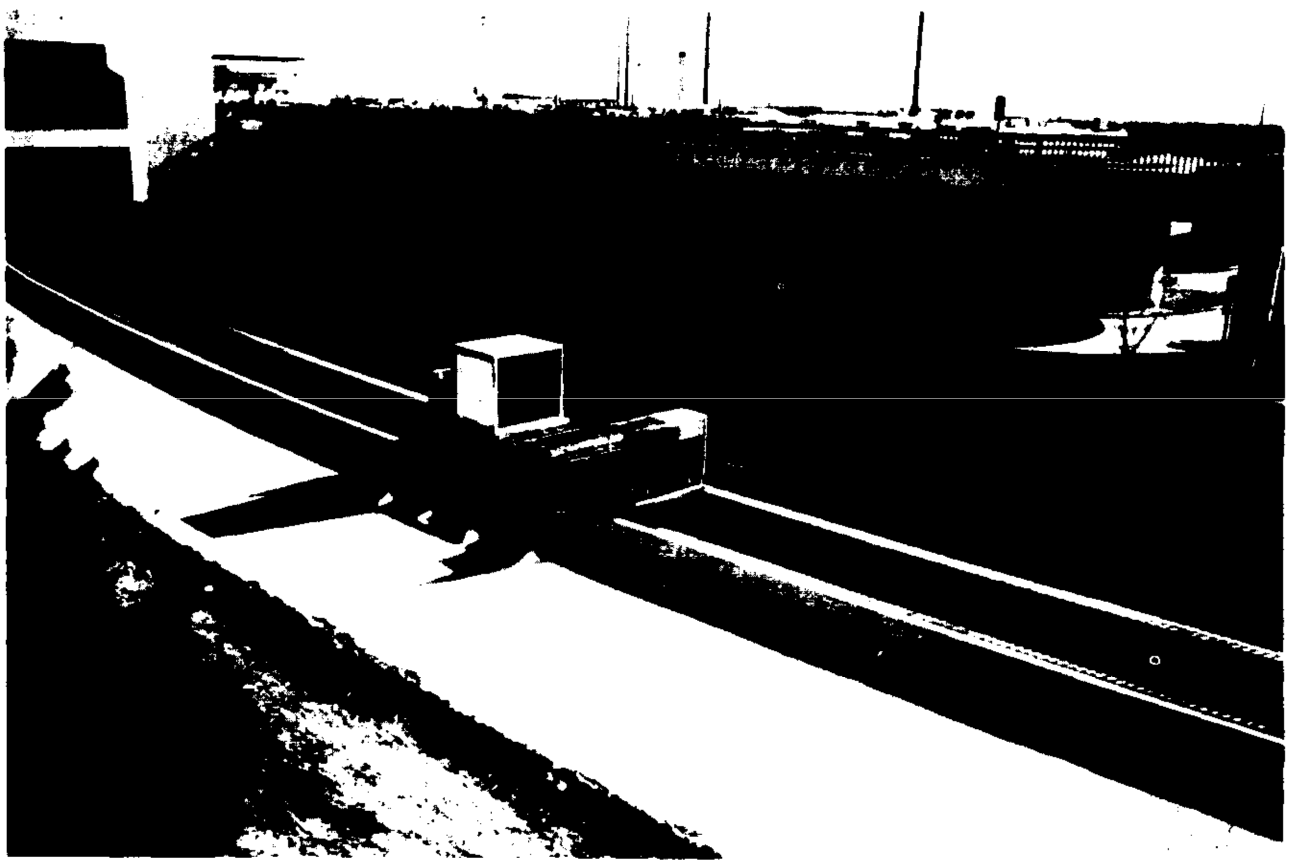

Photo credit OTA staff photo

An AGRT system capable of carrying goods as well as people could reduce costs to provide short inexpensive sidings. In any urban application the type and volume of goods-handling potential will depend on the characteristics of the local economy and the locations of the system.

Unresolved **issue:**

- the potential markets that could use AGT facilities for goods movement.

Nonautomated Guideway Transit Options

AGRT is but one option to improve urban transportation. Its development should not preclude continuing investigations into a number of other promising areas for the future:

- transportation systems management for better utilization of existing passenger vehicles and rights-of-way;
- dual-mode buses or cars that can operate in mixed traffic under manual control and in an automated mode on a guideway;
- automated roadways to free the motorist of the responsibilities of vehicle control and to provide safer operation free of human error and erratic behavior;
- personal rapid transit, an automated guideway mode (see figure 2) with separate small vehicles for each traveler or group of persons traveling together;
- telecommunications research to find ways to reduce the need to travel; and
- alternative land use policies which, in the long run, could affect the need to travel, the length of travel, and the mode of travel by changing the relative proximities and densities of activity centers.

Summary

AGRT is being developed as an additional technology to help cities meet their needs for public transportation. As an alternative to AGRT, Option 1 would upgrade and deploy existing automated guideway technologies for urban use in the near term. The second option would continue further studies while also beginning work on those subsystems that would ultimately be required for an advanced AGT technology. The third option would add to the second by providing a realistic systems environment in which to test these subsystems in integrated operations. The fourth option, representing essentially the program proposed by UMTA in 1978 and subsequently revised would proceed directly with the construction and testing of prototype systems leading to a production-ready technology by the mid-1980's.

This assessment has identified several critical information gaps. The selection of one or more of the first three options would allow more time for analysis of these issues, which could impact many of the design decisions for advanced automated guideway systems. There is also a need to determine further what significant differences exist among the AGRT technologies. For this reason and for reasons of system competition it would seem desirable that development should continue on all technologies until better information becomes available on which to base the selection of preferred alternatives.

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