

CITYCENTER APM
A SYSTEM OF THE WORLD-CLASS METROPOLIS IN LAS VEGAS, NEVADA

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Abstract

MGM MIRAGE Design Group (MMDG) is implementing an Automated People Mover (APM) for the CityCenter. This project is a seven billion dollars (U.S.) world class mixed use urban development located south of Bellagio Resort in the heart of Las Vegas, Nevada. It is the largest privately funded project in US history. The APM will be an important element of the overall CityCenter's experience.

The CityCenter APM system will be a dual-lane shuttle. It has two end stations located at Bellagio and Monte Carlo Resorts, and an intermediate station in the Retail District. The Request for Proposals for the Design-Build portion of the system was issued in December 2005. A system supplier was then selected and Notice-to-Proceed was given in June 2006. This paper describes the approaches and steps involved with planning, procuring and designing for the CityCenter APM. It also discusses the system's current implementation status. In addition, the paper presents the APM's unique design features, challenges, and its integration into CityCenter's surrounding world-class facilities.

Introduction

In November 2004, MGM MIRAGE unveiled a plan to develop a multibillion-dollar "urban metropolis" project named CityCenter. The project is located on the Strip between Bellagio and Monte Carlo Resorts. Major elements of the project include resort hotels, residential condominiums, retail spaces, convention center, theater, parking garages, and an Automated People Mover (APM) system.

The APM system will have three (3) stations and has an initial length of approximately 670 meters (2,200 feet) long. Two end stations are located at Bellagio and Monte Carlo Resorts. The third station is integrated into CityCenter's Retail District, adjacent to the 4,000 room hotel and casino tower at the heart of CityCenter. As part of the world class facility that will shape Las Vegas's future, the APM system, besides its mission to provide transportation services to CityCenter's passengers, is designed with unique appearance and features that will enhance users' experience and add visibility to CityCenter. The following sections describe (1) CityCenter and the APM system; (2) the

process involved with planning and project definition; (3) project implementation; and (4) unique features and challenges.

CityCenter

In November 2004, MGM MIRAGE unveiled a plan to develop a multibillion-dollar “urban metropolis” on the Strip between the Bellagio and Monte Carlo Resorts. CityCenter, with its incredible scale, will eventually function as a master-planned urban complex that will make Las Vegas become a major urban center in the western United States ⁽¹⁾. An aerial photo showing CityCenter site is shown in Figure 1.



Source: MGM MIRAGE

Figure 1 – CityCenter Site

The project exhibits unique high-rise buildings designed by world renowned architects. The first phase of CityCenter will cover a space approximately 1.68 million square meters (18 million square feet) of space. It will include approximately 5,000 hotel rooms, 2,700 condominium units, and 500,000 square feet of entertainment, dining, and retail areas ⁽²⁾. A rendering of CityCenter is shown in Figure 2.



Source: MGM MIRAGE

Figure 2 – CityCenter’s 3-D Rendering

APM Planning and Project Definition

In late May of 2005, MGM MIRAGE Design Group (MMDG) and Gensler of Nevada engaged Lea+Elliott to undertake a comprehensive Planning and Project Definition study for the CityCenter APM system. The initial goals of the study were to plan and develop an APM system that (1) serves transportation needs for CityCenter’s major activity areas and adjacent properties, (2) is feasible and integrates well with current CityCenter’s master plan and designs, and (3) be equipped with state-of-the-art features and equipment to enhance visitors’ and residents’ experience.

As part of this study, major planning components were established to ensure that each issue of APM design and construction was addressed with CityCenter team. These components were alignment, station location and layout, design and construction impacts, aesthetics, system performance, technologies, expansion, and financial considerations. Besides focusing on technical issues, a goal of this study was to ensure an open exchange of information among various parties involved with the project on these planning components so that the owner could make informed decisions. These planning components are discussed below:

Guideway Alignment

The CityCenter's master plan had a significant influence on the APM system alignment. Planned buildings, roadways, existing and future utilities could affect the alignment. Moving these facilities often means a schedule or cost impact. The system alignment was modeled using rail design principles, using curve selection, spirals and tangents. This was an iterative process as there were trade-offs among performance, design/construction impacts, and costs. Given the compact nature of CityCenter, the number of alignment options was limited as there were constraints dictated by the master plan and building designs. The following configurations were assessed for each alignment option:

- Single lane – a single train operating between stations
- Single lane with by-passing – two trains operating in opposite directions bypassing each other at a centrally located dual guideway segment
- Dual lane – two trains operating on two independent guideways
- Pinched loop – multiple trains following one another and crossing from one guideway to another at alignment end locations

Station Locations and Layouts

Similar to guideway alignment, stations locations and layout must integrate well with the master plan and other designs. Other issues considered included structural integration and clearance issues. As for station layout, the following alternatives were considered:

- Center platform – a single platform located at the center between the two guideways
- Side platform – two side platforms located on the outside of the guideway
- Center and Side platform – a combination of both side and center platforms

Design and Construction Impacts

The study addressed impacts and mitigations on current design and future constructions. Integrating APM's elements to CityCenter required collaborative efforts on all parties involved. There were restrictions on platform lengths and widths, maximum curve radius, switch placement, etc. It was critical to identify solutions that provided a balance among constraints and needs. Once mitigation for an impact was determined, it was then assessed against engineering and railway design principles before a solution was recommended.

Performance

The goal for CityCenter APM system was to provide a high performance system. Given relative short distances between stations, optimizing system performance for low trip and short wait times (while meeting capacity) was relatively easy to achieve. During the study, every option was tested using train performance simulations for alignment

comparison and impact assessment, including ride quality. The travel times between stations were simulated and determined at approximately 1 minute. The round trip time was about 320 seconds. For comparison, the round trip time of the previous Yantrack's APM system connecting Bellagio and Monte Carlo was 510 seconds – with one less station. MMDG demolished this Yantrack APM system in 2006 to make room for construction.

Aesthetics

Besides the aesthetics of the APM system itself, the aesthetics relationship between the APM system and the overall CityCenter was an important element of system planning. All aspects of the system, including stations, vehicles, columns, guideway must enhance the view corridors and user experience. For example, aesthetics was a determining factor for the owner to decide on flat guideway and single column approaches.

Technologies

APM technologies played a critical role in defining stations, vehicles, columns, guideway structures, and aesthetic elements. The study considered different technologies that presented key opportunities to the owner such as competition on design concepts, implementation approaches and costs. The following were major technological issues considered:

- Design and construction impacts - some technology categories could present a larger impact on the design of APM and adjacent CityCenter facilities. This could result in some inefficiency such as increased cost, duplicate structures, and increased sizes of facilities.
- Performance – because of short distances, travel times and headways for most technologies were fairly comparable. Also considered were the safety and reliability of operating such systems.
- Technology maturity - this is an important issue as it affects technical, schedule and cost risks.
- Noise and Vibration – these were essential factors for incorporation into CityCenter environment.

System Expansion

Another consideration was the system expansion capability, including whether it was feasible for the planned system to connect all MGM MIRAGE's properties along the west side of the Strip, or a number of adjacent properties.

Financial Consideration

Although there were many requirements applicable to the APM system, an important factor considered was the capital and operation/maintenance costs of the system. The system costs must be within the available budget.

The Planning and Project Definition phase was an important step since its results determined the system’s feasibility and served as the basis for development of system specifications. The following table provides a summary of the system characteristics derived at the conclusion of this phase.

System Length	670m (2,200 ft)
Number of Stations	3 (Bellagio, Retail District, Monte Carlo)
Configuration	Dual Lane/Shuttle
Station Length	Approximately 37m (120 ft)
Station Configuration	Side Platforms
Maximum Curve Radius	76m (250 ft)
Initial System Capacity	3,000 pphpd
Platform Elevation	Approximately 18m (60 ft) from grade level
Substructure	Single columns supporting two guideways

The system alignment and configuration are represented in Figure 3.



Source: MGM MIRAGE

Figure 3 – CityCenter APM Alignment and Configuration

APM Contracting Approach

A major goal in MMDG’s contracting approach was to minimize the number of APM related contracting packages. Minimizing interfaces, conflicts and contractor dependencies were key factors in making contracting assignment. The CityCenter APM system was packaged in accordance with the following:

Operating System Package - included design, manufacture, installation, and test under a single Design-Build-Operate-Maintain (DBOM) contract. The Operating System package

included all mechanical and electrical equipment that comprises the electro-mechanical system (vehicles, control system, communications systems, power distribution system, station equipment, guideway equipment, safety equipment, maintenance facility and equipment room finish-outs, and the maintenance equipment and tools). Also included in this DBOM package was the design and construction of guideway and columns. Due to constructability issues, only columns outside of the Bellagio and Monte Carlo stations were included in the Operating System package.

Fixed Facilities Packages – included stations, and their mechanical and electrical systems, maintenance facility shell, power substation facility, and other structures and civil works associated with and in support of the APM. These packages are designed, procured, and built separately using the conventional design-bid-build method. There were two major Fixed Facilities packages - the first package included the two end stations (Bellagio and Monte Carlo), their supporting structures and other APM related facilities. The second package included the middle station in the Retail District and its related APM facilities.

APM Procurement

Due to project schedule and continued interface requirements with CityCenter's design and construction team, the design development had to continue after the Planning and Project Definition phase. This design development effort took into consideration a wide range of different APM technologies, which assisted with the Design-Build-Operate-Maintain (DBOM) of the procurement documents. One of the key criteria in the development of the DBOM's procurement was to satisfy the owner's business and technical needs, and in the end, provide a quality product. The DBOM's document development process was structured to address all aspects involved with concept, design, fabrication, coordination, installation, verification, operation and maintenance.

The technical specifications were developed that contained performance and some functional requirements. The intent was to specify what the system must deliver (not how), with objectives that are achievable and verifiable. On the commercial side, a competitive one-step best-value approach was used. Proposals were required to submit their technical, management, commercial, and price proposals at one time. The best value process allowed the owner to evaluate criteria related to price, technical design, technical approach, quality of proposed personnel, schedule, financial strength, financing plan, service proven technology, experience, design, management plan, and aesthetics features. Since creative and forward thinking were critical, it was important for proposers to describe any unique and innovative aspects in their proposed system that will attract passengers and provide them with memorable experience. Realizing this critical goal, there were many design concepts submitted by proposers. Many design concepts were very unique and carefully thought out.

The Operating System's Request for Proposal was issued on December 16, 2005. Proposals were due to MMDG on April 13, 2006. After an evaluation period, Doppelmayr Cable Car (DCC) was selected and awarded the DBOM contract.

Once the technology was identified, MMDG's architects and designers were able to advance designs on APM stations and other fixed facilities. MMDG selected Gensler of Nevada to serve as the Architect/Designer for the overall APM Fixed Facilities. Tishman Construction Corporation of Nevada was selected to be the Construction Manager. Lea+Elliott continued to serve as APM Consultant, providing assistance to MMDG and others on APM's technical and management issues. In October, 2006, MMDG selected a joint venture of Clark Construction and Thor Construction for construction work of Bellagio and Monte Carlo stations and related Fixed Facilities. Perini Corporation, General Contractor for CityCenter, was responsible for the construction of the Retail District station which is integrated with the CityCenter's retail facility. By engaging contractors early prior to design completion, MMDG could take advantage of Contractor's input on logistical requirements such as project schedule, constructability issues, and construction materials.

Project Implementation

Project implementation includes design, construction, installation, testing and commissioning. Detailed designs for the Operating System and Fixed Facilities are on-going and expected to be completed in by the end of 2007. Construction of foundations and columns started in December 2006.

APM Design

The CityCenter APM system implementation is proceeding at full speed. The following sections discuss key implementation items related to the Operating System and Fixed Facilities.

The Operating System

The CityCenter APM uses cable technology that will be designed and built by Doppelmayr Cable Car team. DCC has implemented a number of APM systems, including the Mandalay Bay system, one of MGM MIRAGE's properties in Las Vegas. The CityCenter APM will be designed with high performance capability, safety, and reliability of a true transportation system. In comparison to the Mandalay Bay system, the CityCenter APM will have the following:

- Higher speed
- Large vehicle
- Wider vehicle doors
- Stylish vehicle design (customized for CityCenter)
- Improved bogie design
- Maintenance platform (along the system's entire length)
- Improved failed-safe designs
- Improved Automated Train Control (ATC), Automated Train Supervision (ATS), Central Control

- Improved drive system
- Improved power rail design and power regeneration
- Live on-board video surveillance system
- Improved communication design

The Fixed Facilities

The Guideway and Columns

The guideway, which supports and guides the vehicles, is based on DCC's proprietary design. It is made of steel construction and bolted to the crossbeams. The guideway consists of eight (8) sections. Typical guideway depth is 1.7m (5.8 ft). There are sections designed for 2.7m (8.9 ft) depth. This is because of the long spans required for crossing the main roadways. The two guideways are separated by a maintenance platform. For safety reason, this maintenance platform is designed at an elevation 0.75m (2.5 ft) below the vehicle floor level. The center-line to center-line spacing is 7.6m (15.1 ft). There is no grade within the entire alignment. Figure 4 shows a fabricated guideway section at DCC's subcontractor (FKM Technology Contor) manufacturing facility. After coating, this guideway section will be shipped to Las Vegas in early 2007 for installation.



Source: MGM MIRAGE

Figure 4 – Fabricated Guideway Section

The guideway structure is supported by single columns designed by Berger-Abam Engineers, Inc. Most columns are approximately 18.2m (60 ft) high measured from grade level to top of cross beams. At long span locations, the distance from the bottom of the drilled shaft to top of cross beam is measured at 36.6m (120 ft). A typical column has a Y-shaped section, 1.2m by 1.8m (4' x 6 ft). The columns' concept was developed by

Gensler of Nevada to match with the aesthetics of CityCenter. Figure 5 shows a rendering of a typical Y-shaped column supporting the guideway.

Stations

There are two side platforms at each station. Gensler of Nevada is currently designing the two end stations, Bellagio and Monte Carlo. These stations are approximately 36m (120 ft) long and 7.6m (25 ft) wide. Stations will have an open-air design with automatic doors. The design of these stations will present significant emphasis on architectural treatment and unique characteristics of CityCenter.

Other Fixed Facilities

The Maintenance Facility and Central Control rooms are located at the Bellagio ends. Located at this end of the system will be the tensioning and drive equipment rooms and power substation.

Operation and Maintenance

MMDG has planned to perform operation and maintenance right after the system is commissioned. DCC would provide initial training and assistance.



Source – MGM MIRAGE

Figure 5 – Columns and Guideway

Aesthetics Features

As discussed in previous sections, aesthetics is important in all aspects of CityCenter's design. The CityCenter APM is designed to include the following aesthetics features:

- **Stylish Vehicle Design** – The vehicle exterior and interior designs will be customized. DCC and its vehicle supplier, CWA Constructions, have provided a range of vehicle exterior design options that include various treatments that will allow a complete wrap of the bogie and blend in with CityCenter's surrounding facilities.
- **Special Lighting** – A lighting system that runs the entire guideway is currently being evaluated. This lighting system will generate flows of colors in harmony with train movement.
- **Illumesh** – At the location where the guideway crosses the major road leading to CityCenter, a special cladding system will be designed using LEDs projecting on reflective stainless steel surface. The lighting can be programmed in various colors, motion, and even imagery.

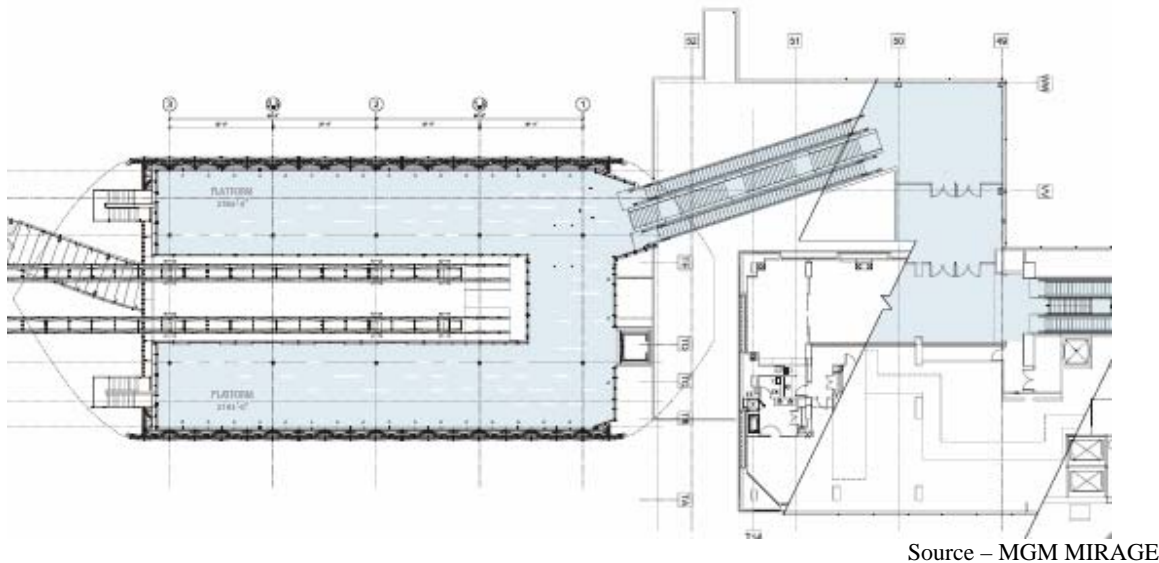


Figure 6 – Bellagio Station Layout

APM Construction

CityCenter is under construction. At the time this paper is written, construction for guideway columns already started. The system is scheduled to be operational in June 2009. The first section of guideway installation is set to begin in 2007. Tishman Construction Corp. is currently representing MMDG on APM construction management. Completion the Monte Carlo station is expected in early 2008. Construction of Bellagio

station is expected to be completed in middle of 2008. Installation of APM system equipment will start prior to completion of these facilities. Figure 7 shows current progress on columns construction.



Figure 7 – Columns Construction

Project Challenges

The design and construction of a transportation system within a large and complex project such as CityCenter bring many challenges. Several issues presented by these challenges are discussed below. Many issues can be related to past APM projects as part of multi-billion dollar construction programs.

- CityCenter is the largest privately funded and complex construction project. Therefore, it is critical to minimize delay possibilities. MMDG's goal is to take advantages of opportunities to begin construction and fabrication prior to completion of full design. For example, several sections of guideway were fabricated prior to completion of all guideway design. The early delivery of these guideway sections allows the APM construction to work with construction schedule of surrounding buildings.
- The APM system touches many major projects within CityCenter. Therefore, it is critical to clearly identify responsibilities among the entities involved in design and constructions. It is also important to have a total team commitment, from all individuals at different levels within the project where everyone works together to find common solutions. Besides encouraging cooperation, MMDG has implemented procedures and control to effectively manage coordination and minimize

uncoordinated work. In addition, the project structure, with clear project responsibilities and delegation of authority, allows MMDG to make quick decision when faced with certain obstacles or issues.

- Although MMDG has minimized the number of APM-related contracts, there are quite a large number of firms involved with the design and implementation of the APM system. Many firms serve as subcontractors. Therefore, there must be significant effort in QA/QC and quality compliance auditing.
- Due to a large number of interfaces between the Operating System and Fixed Facilities and to avoid future problems, detailed interfaces must be controlled and documented. Given the fast paced nature of the project where many designs are matured while construction is in progress, these interfaces must be managed closely. To ensure this vital coordination among various parties, MMDG held weekly meetings with all parties and maintain constant communication. In addition, MMDG has implemented a web-based system project management tool that is expected to accommodate all key functions of project management, facilitating collaboration throughout design and construction.
- Design review and interfaces are critical to the project success. It is important that the Design-Build team management follows through with the submittal and review process, and that all necessary documentations and tracking conform to specifications. Submittal activities must be incorporated into the baseline schedule and that they meet schedule requirement. The relative cost of fixing is many times more expensive on average when detected at later stage of the project or during operation.

Conclusion

The CityCenter APM system is an important element of CityCenter, an incredible urban development of the 21st century. Planning, designing, and constructing the APM system to meet the goals and vision of CityCenter are very challenging, but exceptionally rewarding. This project has been an enriching experience to all participants. By providing necessary resources and funding for the APM project, MGM MIRAGE and MMDG have demonstrated serious commitment to make the APM system a success, which will require dedication and collaboration from all involved.

REFERENCES

- (1) and (2) - CityCenter's public information