

Large station canopies are among the design measures required to adapt the network to the harsh desert environment.



Image: Samsung C&T

Six lines by 2019

MEGAPROJECT The Saudi capital is to have a six-line driverless metro network in five years, according to ambitious plans unveiled last year. With construction about to start, Karol Zemek looks at a flagship rail project for the Middle East.

Construction is about to start on one of the world's largest public infrastructure projects. The 176.4 km metro network in Riyadh has an overall budget of €16.3bn, which is two and a half times the cost of the 444 km Haramain High Speed Railway from Makkah to Jeddah and Madinah (p50). The timescale is equally impressive. All six lines are scheduled to be completed by 2019, just five years after the start of construction.

The project is being funded by the Saudi government through the Public Investment Fund. Project promoter Arriyadh Development Authority says that the network will transform

the city. Speaking at the award of construction contracts, ADA President Ibrahim Bin Muhammad Al Sultan called the metro 'a major driver of employment and economic development', adding that 'this is the biggest infrastructure project to be undertaken in the Kingdom of Saudi Arabia and is a cornerstone of the bold future we envision for our city'.

Riyadh is not a complete newcomer to urban rail; in 2012 a driverless metro opened in Princess Nora Bint Abdul Rahman University (RG 9.12 p31), and plans for an equivalent at King Saud University were announced the following year (RG 5.13 p20). However, a heavy metro with

significant lengths of tunnel is on an altogether different scale from a campus peoplemover.

A city-wide network

The metro is expected to enhance the city's economic dynamism and improve the quality of life for its residents. The population of 5.7 million, which has doubled since 1990, is expected to grow to 8.3 million by 2030. This has led to saturation on the roads, and the third aim of easing traffic congestion is perhaps the most urgent. The only public transport on offer at the moment is an underdeveloped minibus network, used for only 2% of the city's 7.4 million daily commuter journeys.

The metro will pass through some of the most congested areas of the city. There are to be six standard-gauge lines and a total of 87 stations across the network, all of which will be air-conditioned. Most lines are to serve the modern business district in the north of central Riyadh, which is far less pedestrian-friendly than the historic centre further south.

The landmark King Abdullah Finance District station will be the western terminus of lines 4 and 6, which are to share a route before Line 4 branches off to the north to serve Princess Nora Bint Abdul Rahman University and King Khaled

South Korean construction firm Samsung C&T expects to take the lead in building the elevated sections of lines 4, 5 and 6.



Image: Samsung C&T

International Airport. Line 6 would run south to meet lines 2 and 3. Lines 4 and 6 would share a depot.

The largest part of Line 4's alignment, 16.7 km, will be elevated, with 6.9 km at grade and 5.9 km in cut-and-cover tunnel. Around two-thirds of the 29.9 km Line 6 will be elevated, with a further 8.5 km in cut-and-cover tunnel and the remainder at grade.

King Abdullah Finance District will also be served by the 38 km north-south Line 1, which will connect it with the business district of Olaya to the south. About 17.5 km of the route will be in bored tunnel, and 15.6 km elevated, with the remainder at grade. There will be 26 stations.

Also serving Olaya is Line 5, which would run mainly along King Abdul Aziz Road, providing interchange with Line 2 at its northern end and Line 1 at its southern end. It will run entirely underground, with about 10 km in bored tunnel. Three TBMs are to be used.

Lines 2 and 3 are the main east-west routes. Line 3 is the longest on the network, at 40.7 km. Nearly two-thirds of this would run on elevated alignment, with 6.2 km in bored tunnel, 3.2 km in cut-and-cover tunnel and 5 km at grade. Because of its length, it will have a depot plus two stabling areas. The line in the southern part of the city will have 22 stations.

Line 2 would run along King Abdullah Road for 25.3 km with 16 stations. Most of the line would be at grade in a road median strip, with only 5.3 km elevated and 3 km in bored tunnel. There would be 16 stations, and interchange would be provided with lines 1, 5 and 6. As with Line 1, Line 2 is to have a depot at one end and a stabling facility at the other.

Three works packages

The programme has been divided into three packages. The first is for lines 1 and 2, the second for Line 3 and the third for lines 4, 5 and 6. Arriyadh Development Authority announced the winners of the construction contracts on July 29.

A US\$9.45bn design and build turnkey contract for lines 1 and 2 was awarded to the BACS consortium led by Bechtel and including Almagbani General Contractors, Consolidated Contractors Co and Siemens.

Siemens' €1.5bn share of the contract includes rolling stock, signalling



Alstom Transport is to supply 69 automated trainsets for the three lines being built by the FAST consortium.

and electrification equipment. The signalling and WLAN-based train control system will be designed to support unattended driverless operation with 90 sec headways, giving a capacity of 21 000 passengers/h. Siemens will supply 31 interlockings, fit out the operations control centre and train the future staff. The power supply will have diesel generators to provide emergency back up.

The Arriyadh New Mobility consortium was awarded a US\$5.21bn contract to design and build Line 3. The consortium comprises two groups. The electrical and mechanical equipment is to be delivered by the Electrical Work Group comprising Ansaldo STS and Bombardier Transportation. Infrastructure will be delivered by the Civil Work Group of Salini-Impregilo, Larsen & Toubro and Nesma.

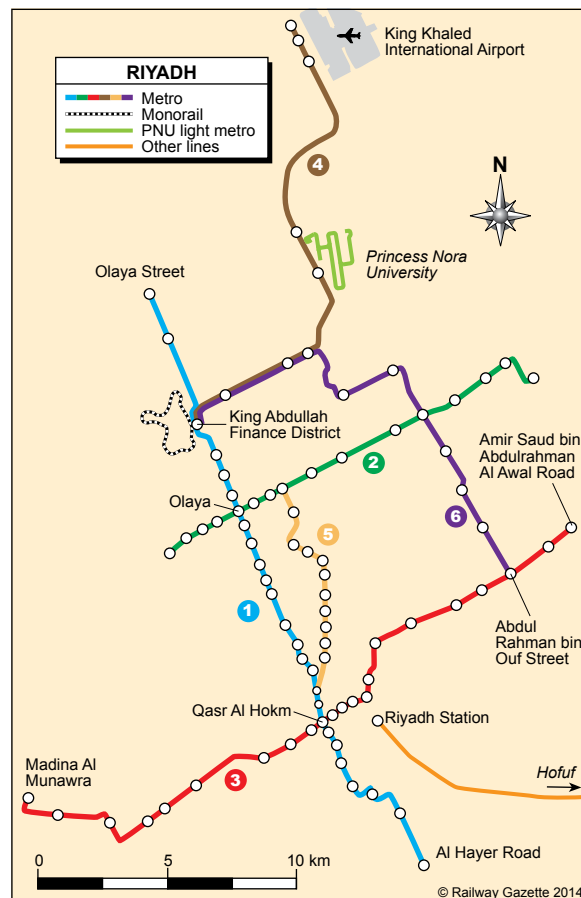
The consortium is led by Ansaldo STS, with a US\$680m share of the contract. This includes provision of automation systems, CBTC, third rail power supplies, the control centre, telecoms and fitting out the depots.

The consortium is also to build the landmark Qasr Al Hokm and Western stations, taking the total value of the works to US\$5.9bn. There is also a potential option worth US\$249m for 10 years of maintenance of the line.

The Riyadh Metro Transit Consultants joint venture of Parsons, Egis and Systra was awarded a US\$556m contract for project management and construction supervision for lines 1, 2 and 3. Each of the three joint venture partners has roughly a one-third share of this, with Parsons as leader with a slightly larger stake. At the peak of work, 650 people from RMTTC will be working in Riyadh; 150 are already there.

The FAST consortium led by Spanish construction group FCC and including Samsung C&T, Alstom, Strukton, Freyssinet Saudi Arabia, Tyspa and Setec is to build lines 4, 5 and 6 for US\$7.82bn.

Within the consortium, FCC, Samsung, Strukton and Freyssinet are in charge of civil works. In order to meet the short construction deadline, each of these companies would concentrate on their key strengths — for example, Samsung intends to take the technical lead on construction of elevated



Lines 1 and 2 are to be operated by a fleet of 74 Siemens Inspiro cars.

alignments. The South Korean company tentatively expects to bring together a multidisciplinary team from its home market, North America, the Philippines, UAE and Qatar.

A joint venture of WS Atkins and Typsa is to design lines 4, 5 and 6 together with Setec. This is worth £75m to lead designer Atkins.

The Riyadh Advanced Metro Project Execution & Delivery joint venture of Louis Berger (55%) and Hill International (45%) is to project manage construction of these three lines under a US\$264m contract. Hill International estimates that 300 of its staff will be present at the peak of the project.



Image: Siemens

Three suppliers, one train design

Each line will be operated by driverless trains that will offer first, family and standard class accommodation, as well as wi-fi. Even though the vehicles will come from three suppliers, ADA has decided to implement a unified design for all trainsets, albeit with a different colour for each line.

Siemens is to supply 74 Inspiro metro cars in two- and four-car sets for lines 1 and 2. The air-conditioned trainsets will have aluminium bodyshells, a top speed of 90 km/h, and regenerative braking. The bogies, traction systems, brakes and doors will have seals and filters designed to reduce sand ingress.

Bombardier Transportation's US\$383m share of the contract for Line 3 includes the supply of 47 two-car driverless Innovia Metro 300 trains with Mitrac traction equipment.

Alstom's €1.2bn share of the contract for lines 4, 5 and 6 includes supplying 69 two-car Metropolis automated trainsets 36 m long and 2710 mm wide. It is also providing Urbalis signalling, its Appitrac

mechanised tracklaying technology and HESOP substations which allow regenerated electricity to be returned to the grid.

Station design

Before the construction contracts were awarded, ADA selected designs for three of the main interchanges. These 'will transform Riyadh streets as they become the most visible elements of the city's new world-class public transport system'. The winning proposals were chosen based on their 'outstanding conceptual thinking and powerful design', with the stations intended as 'tranquil oases for travel, shopping and dining' to place the metro at the heart of city life.

King Abdullah Finance District will be designed by a consortium of Zaha Hadid Architects; structural, fire and services engineer Buro Happold; cost consultant Davis Langdon; and façade consultant NewTecnic. The 20 434 m² station will have four public levels and two levels of underground car parking. It would be at the centre of a network of footpaths, bridges and metro lines, with clearly delineated pedestrian routes to optimise circulation. The plans include a bridge to reach a 3.6 km driverless monorail which will provide local transport within the financial district when it opens in 2016 (p51).

A design by Gerber Architekten of Germany was selected for Olaya station at the intersection of lines 1 and 2. The station will feature elevated public gardens and an undulating roof inspired by desert sand dunes. A large, open entrance hall will allow visitors to see across all four storeys of the building, including the two

sets of metro platforms, a mezzanine level with shops and food halls and an open concourse housing the ticket barriers. The design was developed in partnership with structural engineers Bollinger & Grohmann and specialist companies BW-Engineers, Thurm & Dinges, DS-ABT, Karajan, Design Fire Consultants and Sweett Group.

Snøhetta of Norway is to design the Qasr Al Hokm interchange between lines 1 and 3 at the intersection of Al Madinah Al Munnawarah Street and King Faisal Street. A large canopy would create a shaded plaza and allow natural light to filter down to the underground concourse. It will also 'respectfully' house Eid Mosque at its southwest corner.

The challenges of the desert

Building such a large network on such a short timescale would be a challenge anywhere, but the local conditions add a layer of complexity. 'The environment is a specific one, and there have not been many metro projects in the desert', points out Wadii Bouchiha, Commercial Director for the Middle East region at Systra. Temperature and sand ingress are the two main factors for which equipment has to be adapted. Systra will use its experience from Dubai and Makkah, which are so far the only desert cities with operational metros in the Middle East.

Samer Tamimi, Vice-President of Hill International's Abu Dhabi office, draws comparisons between this project and the Doha metro, on which Hill is also working. 'The technical difficulties will be the same, but the culture is the same too. The scale is bigger in Riyadh, though.' ❏

Table I. Riyadh metro

Line	Route	Length km
1 Blue	Olaya Street – Batha Street – Al Hayer Road	38.0
2 Green	King Abdullah Road	25.3
3 Red	Madina Al Munawra – Amir Saad bin Abdul Rahman Al Awal Road	40.7
4 Orange	King Abdullah Finance District – King Khaled International Airport	29.6
5 Yellow	King Abdul Aziz Road	12.9
6 Purple	Abdul Rahman bin Ouf Street – King Abdullah Finance District	29.9
Total		176.4