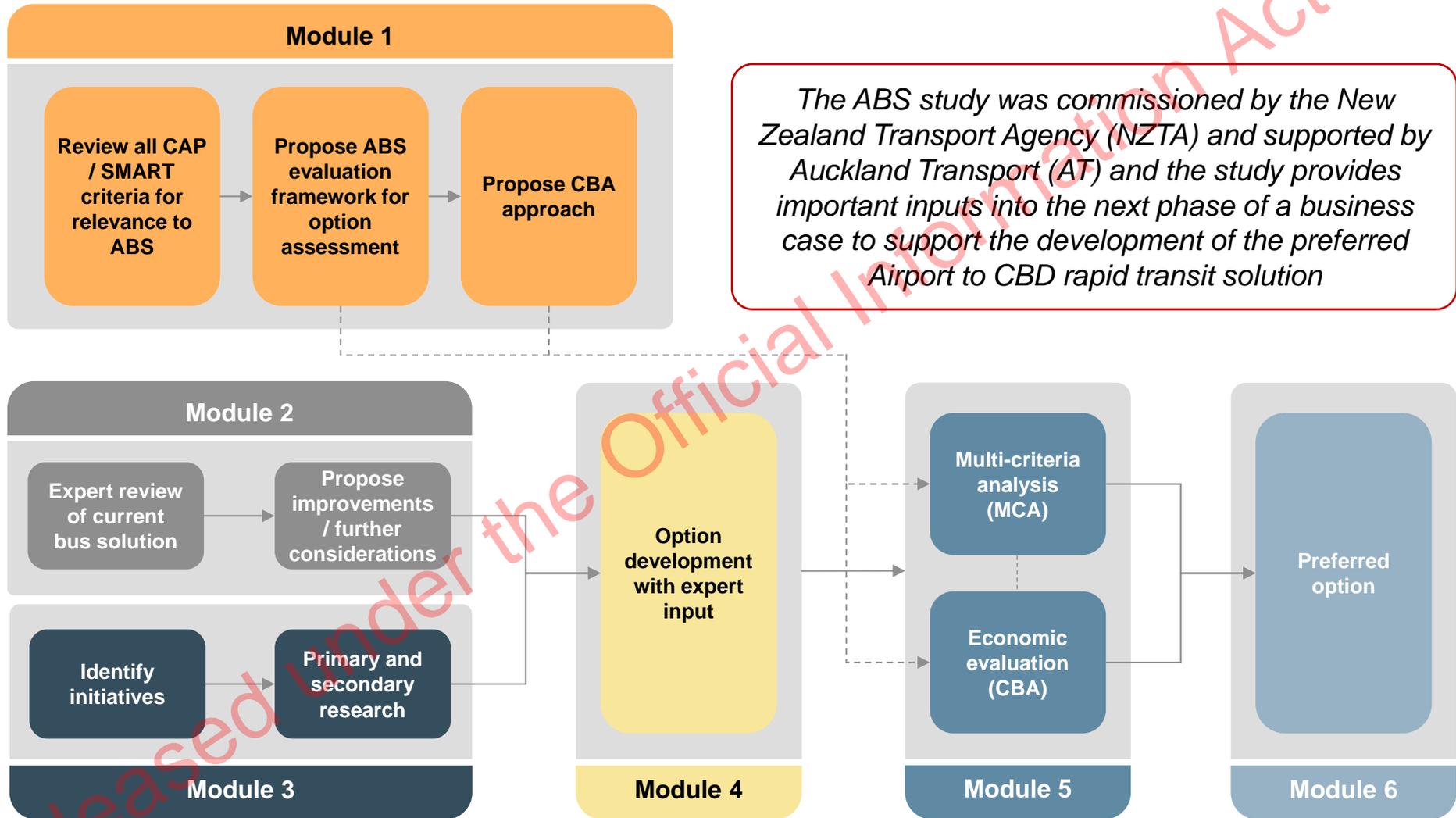
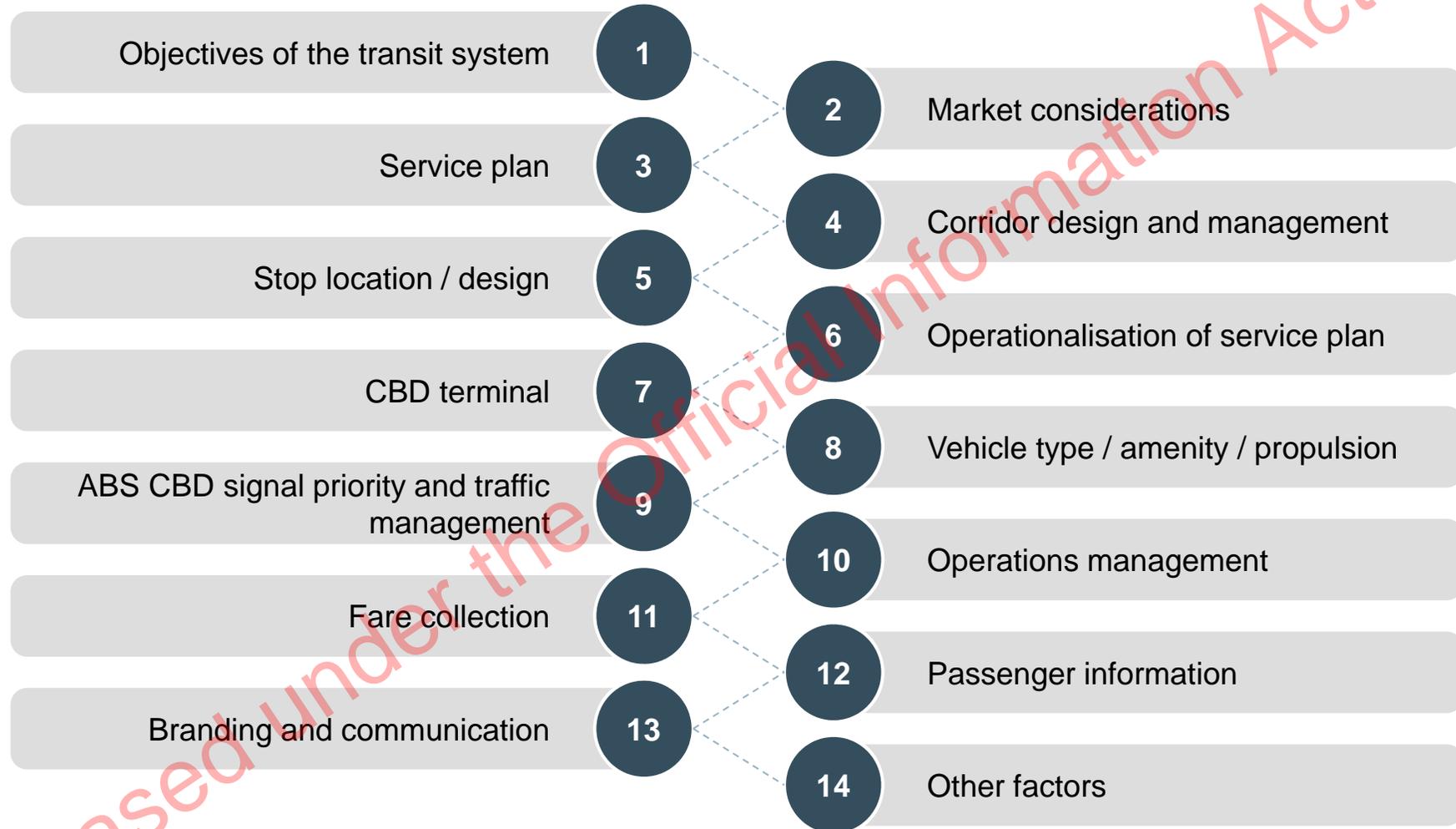


The Advanced Bus Solution (ABS) study comprised six modules completed over an 11 week period between October and December 2016



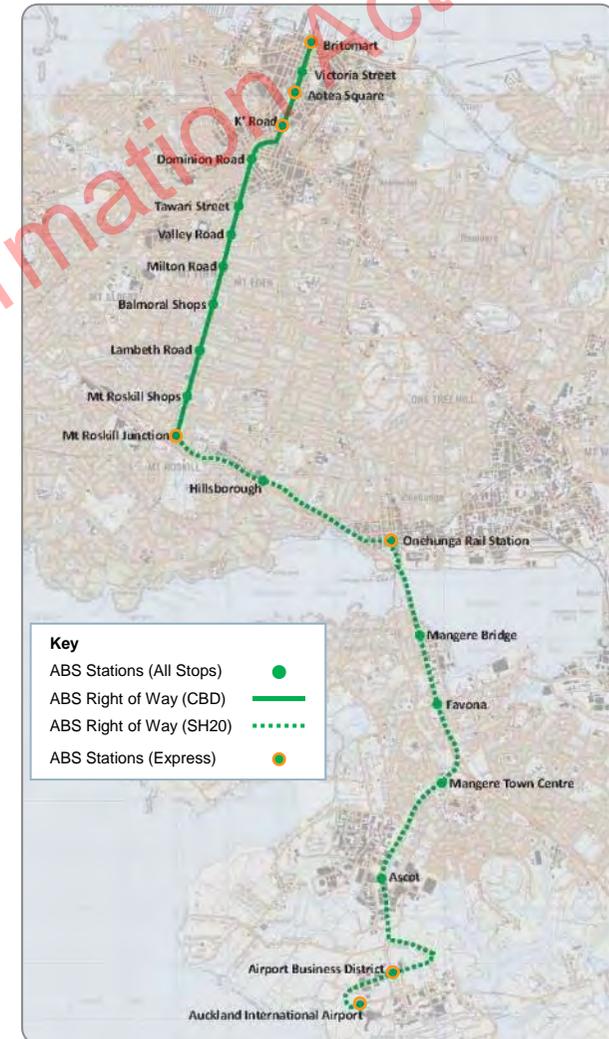
Two ABS options were developed leveraging 14 key design principles developed by the L.E.K. team and our global rapid transit experts



The base case provides for the establishment of an advanced bus solution between the CBD and Airport utilising Dominion Rd (AART)

Auckland CBD – Airport Rapid Transit (AART)

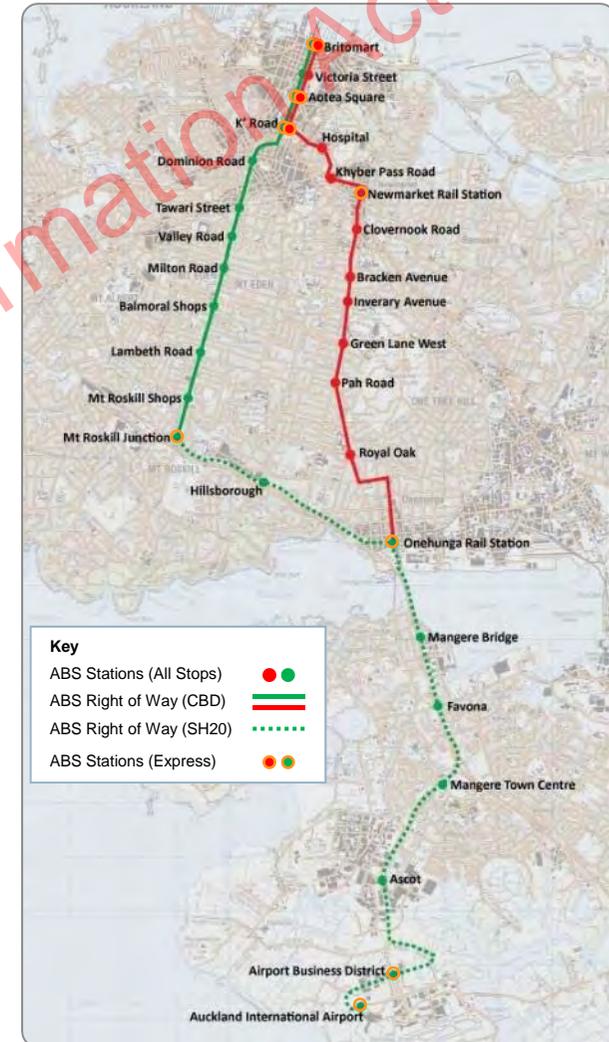
- The 'Auckland CBD – Airport Rapid Transit' (AART) option comprises three different types of service along the Dominion Rd corridor:
 - an 'all stops' service every four minutes (15 services per hour) from Mt Roskill Junction to Mt Roskill Junction via Britomart
 - an 'all stops' service every four minutes from the Airport to Airport via Britomart
 - two 'express' services every four minutes from the Airport to Airport via Britomart, only stopping at the express ABS stations
- Seven express ABS stations have been chosen, i.e. Britomart, Aotea Square, Karangahape Rd, Mt Roskill Junction, Onehunga Rail Station, Airport Business District and the Airport
- Key characteristics of the AART option include:
 - a public transport mall on Queen St from Customs St to Mayoral Dr
 - the use of median and parallel offset median stations along Dominion Rd (located at major traffic signal controlled intersections that allow for pedestrian access)
 - the use of median dedicated rights of way
 - the use of 18m articulated, specialised ABS vehicles (100 persons per vehicle; 60 seated and 40 standing) for 'all stops' services and double-decker ABS vehicles (100 persons per vehicle; 85 seated and 15 standing) for 'express' services
 - the use of hybrid vehicles at a minimum, with a gradual transition to all electric vehicles
 - off-board ticketing



The base case was assessed against an option leveraging both Dominion Rd and Manukau Rd (AART+)

Auckland CBD – Airport Rapid Transit Plus (AART+)

- The 'Auckland CBD – Airport Rapid Transit Plus' (AART+) option comprises five different services along the Dominion Rd and Manukau Rd corridors:
 - an 'all stops' service every four minutes (15 services per hour) from Mt Roskill Junction to Mt Roskill Junction via Britomart along Dominion Rd
 - an 'all stops' service every four minutes from the Airport to Airport via Britomart along Dominion Rd
 - an 'all stops' service every eight minutes (7.5 services per hour) from the Airport to Airport via Britomart along Manukau Rd
 - an 'express' service every four minutes from the Airport to Airport via Britomart along Dominion Rd, only stopping at the express ABS stations
 - an 'express' service every eight minutes from the Airport to Airport via Britomart along Manukau Rd, only stopping at the express ABS stations
- Eight express ABS stations have been chosen, i.e. Britomart, Aotea Square, Karangahape Rd, Mt Roskill Junction, Newmarket Rail Station, Onehunga Rail Station, Airport Business District and the Airport
- Key characteristics of the AART+ option include:
 - a public transport mall on Queen St from Customs St to Mayoral Dr
 - the use of kerbside and lateral offset median stations along Dominion Rd and Manukau Rd (located at major traffic signal controlled intersections that allow for pedestrian access)
 - the use of median dedicated right of way on Dominion Rd and kerbside ROW on Manukau Rd
 - the use of 18m articulated, specialised ABS vehicles (100 persons per vehicle; 60 seated and 40 standing) for 'all stops' services along Dominion Rd and double-decker ABS vehicles (100 persons per vehicle; 85 seated and 15 standing) for 'all stops' services along Manukau Rd and all 'express' services
 - the use of hybrid vehicles at a minimum, with a gradual transition to all electric vehicles
 - off-board ticketing



The multi-criteria analysis (MCA) did not identify a clear preference for either AART or AART+

Multi-criteria analysis of AART+ relative to AART, unweighted basis (summary)

Theme	Sub-theme (if applicable)	AART+ relative to AART	Commentary	AART+ relative to AART
1 Economic growth		Minor positive impact	AART+ serves a larger catchment than AART along two corridors (Dominion Rd and Manukau Rd) and provides additional capacity	Overall MCA assessment
2 Network efficiency, reliability and resilience	A To / from Airport and city centre	Minor positive impact	Both options provide similar benefits for travel between the Airport and city centre, with AART+ providing additional reliability benefits and increased patronage	<p><i>AART+ provides some additional benefits relative to AART because AART+ operates over two corridors, serving a larger catchment and providing additional capacity. However, AART+ will be more difficult and costly to implement and operate than AART</i></p> <p><i>The MCA did not clearly distinguish between the two ABS options</i></p>
	B In the Mangere-Otahuhu area	Minor positive impact	Both options provide a similar function in the Mangere-Otahuhu area, with AART+ providing additional connections to multiple corridors	
	C In the city centre	Minor positive impact	AART+ operates along multiple corridors and so provides some additional benefits to AART in the city centre	
	D New technology	No significant impact	There is no significant difference between the options in terms of new technology	
3 Liveability and safety	A To / from Airport and city centre	No significant impact	There is no significant difference between the two options except that there is a higher potential for enhancements across multiple corridors	<p><i>All 75 evaluation criteria were assessed and details have been included in the Appendix</i></p>
	B In the city centre	Minor negative impact	There is a minor difference between the two options in terms of liveability and safety in the city centre as AART+ has more vehicles operating along Queen St	
4 Environmental sustainability		Minor positive impact	AART+ provides slightly higher noise and emissions benefits than AART	
5 Implementability		Minor negative impact	AART+ is expected to be more difficult to implement than AART	
6 Investment affordability		Minor negative impact	AART+ has a higher cost in net financial terms compared to AART	

Key: Major negative impact (orange), Minor negative impact (yellow), No significant impact (grey), Minor positive impact (light green), Major positive impact (dark green)

Source: L.E.K. analysis; Auckland Transport SMART Business Case; CAP programme business case

The CBA evaluated 11 criteria in order to determine the incremental benefit delivered by AART+ over AART

Economic evaluation for ABS: Basis of quantification

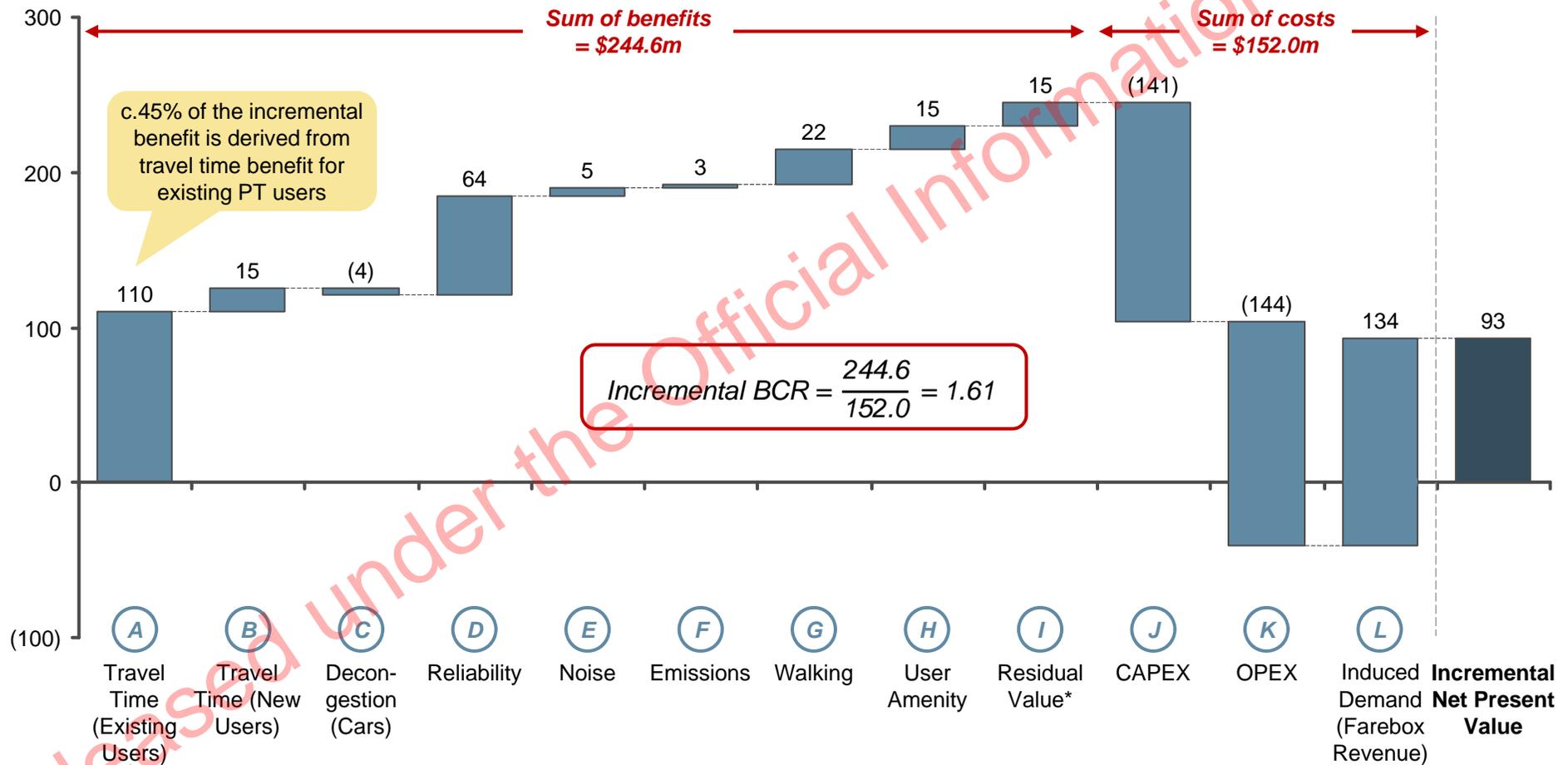
Key benefits that were assessed via the CBA		
1	<i>Travel time benefits</i>	Value of travel time savings to existing and new bus users due to improved average speed
2	<i>Traffic decongestion benefit</i>	Value of reduced level of road traffic congestion in the network
3	<i>Reliability benefits</i>	Value of reduced variability in bus journey times to existing and new bus users
4	<i>Noise benefits</i>	The value of public health benefits (sleep and speech disturbance, stress and psychological impacts) due to reduced ambient noise from buses (e.g. progressive introduction of electric buses)
5	<i>Emissions benefits</i>	Value of reduction in emissions based on a defined price for CO ₂ , NO _x and PM ₁₀ from buses (e.g. progressive introduction of electric buses), and from passengers diverted from cars to public transport
6	<i>Walking benefits</i>	The health benefit new users gain from walking to bus stops
7	<i>User amenity benefits</i>	Value of the attributes of bus services and infrastructure to new and existing bus users
8	<i>Residual value benefit</i>	Remaining value of initial infrastructure investment at the end of the analysis period (net present value)
9	<i>Capital investment (CAPEX)</i>	Value of initial investment in order to achieve desired benefits
10	<i>Operating costs (OPEX)</i>	Value of operating costs in order to maintain desired benefits
11	<i>Induced demand (farebox revenue)</i>	Value of additional farebox revenue resulting from induced demand on buses

Source: NZTA Economic Evaluation Manual; L.E.K. analysis

When compared with AART, AART+ is estimated to generate an incremental benefit of \$93m in net present value terms (2016 prices) and an incremental BCR of 1.61

Incremental benefit of AART+ over AART, by type (NPV) (2016)

Millions of NZD



Note: * The residual value is the net present value (in 2016) of the remaining value of the infrastructure capital expenditure in 2046. The value of the infrastructure in 2046 is calculated using straight-line depreciation over 40 years and is thus 50% of the original capital expenditure

Source: NZTA Economic Evaluation Manual; JMAC ART3 / APT3 model output; L.E.K. analysis

The sensitivity of the CBA was flexed across three metrics, indicating an incremental NPV range of \$37m – \$185m (2016 prices)

Metric	Assessment range	Incremental Net Present Value	Incremental BCR
<i>Discount rate</i>	4%	\$184.9m	2.07
	8%	\$37.4m	1.28
<i>Capital expenditure</i>	-25%	\$124.3m	2.07
	+25%	\$61.1m	1.33
<i>Operating expenditure</i>	-25%	\$128.8m	2.11
	+25%	\$56.6m	1.30

Source: NZTA Economic Evaluation Manual; JMAC ART3 / APT3 model output; L.E.K. analysis

The MCA does not provide a strong rationale for one option over another while the CBA favours AART+ over AART

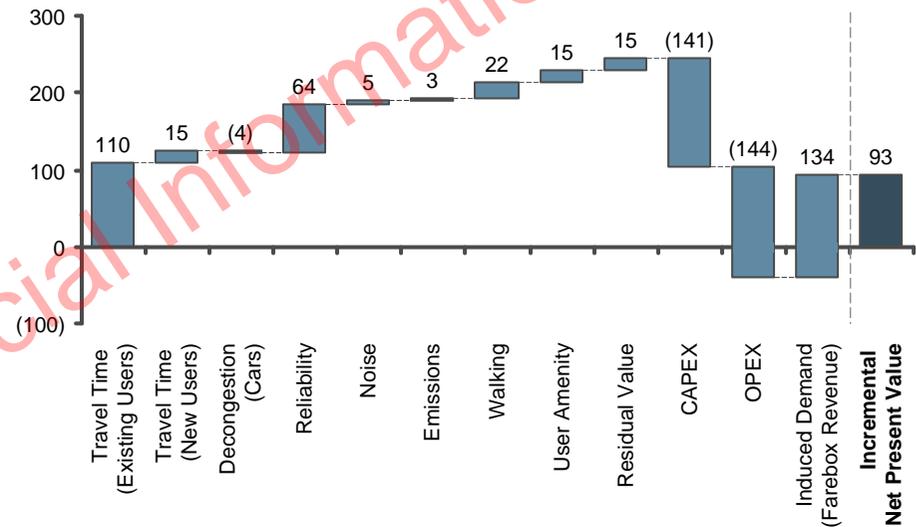
Option MCA

Option CBA

Theme	Sub-theme (if applicable)	AART+ relative to AART
Economic growth		Minor positive impact
Network efficiency, reliability and resilience	To / from Airport and city centre	No significant impact
	In the Mangere-Otahuhu area	Minor positive impact
	In the city centre	Minor positive impact
	New technology	No significant impact
Liveability and safety	To / from Airport and city centre	No significant impact
	In the city centre	Minor negative impact
Environmental sustainability		Minor positive impact
Implementability		Major negative impact
Investment affordability		Major negative impact
Overall assessment		No significant impact

Incremental benefit of AART+ over AART, by type (NPV) (2016)

Millions of NZD



Incremental Net Present Value: \$92.7m

Incremental BCR: 1.61

AART+ provides some additional benefits relative to AART because AART+ operates over two corridors, serving a larger catchment and providing additional capacity. However, AART+ will be more difficult and costly to implement and operate than AART. The MCA did not clearly distinguish between the two ABS options

AART+ provides a greater catchment area, which is the primary driver for the travel time and induced demand benefits. This more than offsets the additional capital and operating costs associated with the delivery of AART+

Key: Major negative impact (Orange), Minor negative impact (Yellow), No significant impact (Grey), Minor positive impact (Light Green), Major positive impact (Dark Green)

Source: NZTA Economic Evaluation Manual; JMAC ART3 / APT3 model output; L.E.K. analysis

There are a number of additional steps that need to be taken to further develop AART and AART+ for the business case development process

<i>Integrated service planning</i>	<ul style="list-style-type: none"> ● Integration and optimisation required for the ABS network and the New Network solution, such that PT patronage can be maximised whilst meeting appropriate levels of customer amenity
<i>Overtaking</i>	<ul style="list-style-type: none"> ● For both AART and AART+ the service plan proposals used for the base assessment have sought to utilise all stops and express services such that passing will be required; as such this report includes some additional visualisation of these options – however the use of a microsimulation or detailed animation package may be required to aid operational understanding in the future
<i>CBD layover optimisation</i>	<ul style="list-style-type: none"> ● Identified strategies to minimise and/or optimise the CBD layovers through a range of initiatives (e.g. utilising airport layovers, CBD through running, virtual layovers, etc.) require further evaluation ● Overnight storage of a number of buses are required for the 5am start time from Queen St and this would need to be associated with the ability to re-fuel and clean vehicles as necessary
<i>Traffic management</i>	<ul style="list-style-type: none"> ● Further detailed analysis will be required to understand and develop appropriate mitigation strategies for both general traffic and bus traffic more specifically (e.g. intersection micro-simulation analysis), accounting for advanced ITS technologies ● Integration of the proposals with the cycle network and provision for cycle parking at key interchanges where park and ride is proposed
<i>Vehicle type / propulsion</i>	<ul style="list-style-type: none"> ● Timing for technology shifts in propulsion requires detailed analysis into the pro's and con's of the opening year choices versus the 2036 or 2046 requirements; e.g. full electric vehicles are heavier than hybrid electric due to larger batteries and this may mean axle loadings are exceeded with less passengers ● Service planning may include removal of full electric in off peak times and operate in peak hours only ● Larger scale buses are being developed to meet urban demand for BRT and exceed now 300 passengers, such proposals may provide significant rapid transit capacity without the need to increase frequencies or platoon buses
<i>Route alignment and stop location</i>	<ul style="list-style-type: none"> ● Further analysis and review should be completed to “fine tune” the advanced bus solution (e.g. to optimise demand, minimise any adverse general traffic impacts – potentially confirmed via intersection micro-simulation modelling, etc.) ● Consideration of the opportunity for grade separation of major east – west intersections and routes for reduced conflict with ABS buses
<i>Demand modelling</i>	<ul style="list-style-type: none"> ● Further model runs are likely to be appropriate to optimise expected demand, having regard to the impact on the assessed economic merit via the CBA
<i>CBA and MCA</i>	<ul style="list-style-type: none"> ● It is likely that many of the cost and benefit line items derived for the preferred advanced bus option will require further refinement before being “fit for purpose” for comparison against any alternative rapid transit proposal