-------- Forwarded Message --------
From: Rob Means <rob.means@electric-bikes.com>
To: Steve McHarris <smcharris@ci.milpitas.ca.gov>
Cc: Ned Thomas <nthomas@ci.milpitas.ca.gov>, Steve Chan <schan@ci.milpitas.ca.gov>, Larwence Fabian <lfabian21@gmail.com>
Subject: how ARUP arrived at their ATN projected cost of $758M for 6.4 miles
Date: Thu, 04 Oct 2018 17:43:44 -0700

Steve,

Here is how ARUP arrived at their ATN projected cost of $758M for 6.4 miles and 10 stations ($118M/mile). Using my estimate of only $15M/mile, I expected a number closer to $96M for the entire 6.4-mile system.

There are 2 major factors that led to this divergence: 1) the hardware was assumed to be much bigger than the PRT flavor I am pursuing, and 2) they added a huge risk factor. As then-Director of Transportation Hans Larsen put it in his October 17, 2012 memo: "Using industry best practices, Arup developed conservative base cost estimates and added a sizeable risk contingency (134% of the base cost) to account for the as yet unknown factors."

Using Aerospace’s suggested high-capacity (large) vehicles, Arup classifies the cost estimate at a Level 5 Rough Order of Magnitude. "Level 5 is the most conceptual level of estimate and includes the highest levels of contingency. The Feasibility Study is technology-neutral, analyzing feasibility on the basis of the widest track requirements, largest minimum turn radii, and heaviest vehicles. Tradeoffs have also been made in the alignment development process to favor larger turn radii to support higher operational speeds, with consequently higher costs. In future phases of study and design, the cost estimate would be refined, and contingencies likely reduced, as more detail is made available."

Going big created a need for bigger physical support. For example, they calculate substructure costs for 4’ diameter drilled concrete piles, 50’ deep, with 295 pounds of rebar per cubic yard of concrete. I anticipate 2’ diameter and much shorter pilings for our PRT. Likewise, their stations seem to cost about 4 times what I expect for our stations. Arup also plans for 47 (expensive) vehicles/mile rather than the 30 (inexpensive) vehicles/mile I anticipate starting with.

On page 28 of Appendices B through E (Main Worksheet – Build Alternative), Arup estimated the following costs for the airport system:

10 GUIDEWAY & TRACK ELEMENTS = $103.7M (Guideway cost/mile = $16.2M)
20 Aerial station, stop, shelter, mall, terminal, platform: $38.9M for 10 stations ($6M/mile)
30 Support Facilities = $8.9M ($1.4M/mile)
40 SITEWORK & SPECIAL CONDITIONS = $21.8M ($3.4M/mile)
50 SYSTEMS = $31.8M ($5M/mile)
Construction Subtotal (10 – 50) = $204.7M ($32M/mile)
70 VEHICLES = $130K each x 300 = $39M, or 47 vehicles/mile ($6M/mile)
80 PROFESSIONAL SERVICES (applies to Cats. 10-50) = $36.7M ($5.7M/mile)
Subtotal (10 – 80) = $280.4 ($43.8M/mile)
90 UNALLOCATED CONTINGENCY = $43.7 ($6.8M/mile)
Subtotal (10 – 90) $324.1M total project cost ($50.7M/mile)

However, there are also minor factors that led to the $280M for the hardware before adding the high levels of risk that we are unlikely to incur. Specifically, ARUP made allowances of 11% ($22M) in their estimate for sitework & special conditions (utility relocation, sound walls, parking, access), the majority of which will not be needed for the proposed Milpitas project. Adding another 15% Unallocated Contingency brings Arup's total project cost estimate to $324M ($50.7M/mile).

Then comes the risk adjustment:

> ESTIMATED COST SCENARIO 1 (30th @Risk Percentile) = $537M (or $84M/mile)
> **ESTIMATED COST SCENARIO 2 (80th @Risk Percentile) = $758M (or $118.5M/mile)**
> ESTIMATED COST SCENARIO 3 (95th @Risk Percentile) = $909M (or $142M/mile)

The 80th percentile scenario reflects the view generally taken by the Federal Transit Administration (FTA) and implies a 20% chance that the costs will be higher than the value presented – and 80% chance it will be lower.

Below, I have included the background information that I culled from the various memos/reports in case you want more detail.

As I start to think about how to finance and structure a PRT company, I am starting to look for models. SVCE seems to have a model that allows for making a profit, and re-using that profit for the benefit of the community. The profit part makes me think that - unlike most JPAs - SVCE is not a government agency. If it was, I would think the profit part would run afoul of the same rules (Prop. 218) that force the City to merely cover costs in their pricing structure. Do you have any thoughts on how to structure a community-owned PRT company?

Assuming that this satisfies my offer to find out why Arup's cost estimate was so high, how are you and Ned coming with your action items?

--

Rob Means, Secretary
Sunnyhills Neighborhood Association
www.SunnyhillsNeighborhood.org
408-262-0420, SNA@electric-bikes.com
1421 Yellowstone Ave, Milpitas, CA 95035-6913
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http://www.sanjoseca.gov/DocumentCenter/View/14332

TO: TRANSPORTATION AND ENVIRONMENT COMMITTEE

FROM: Hans F. Larsen

SUBJECT: AUTOMATED TRANSIT NETWORK FEASIBILITY STUDY

DATE: October 17, 2012

…

ATN proponents have asserted that ATNs would be less expensive to build than traditional rail due to smaller tracks, stations, vehicles, and right of way requirements and less expensive (and more environmentally-friendly) to operate due to automation and electrically-powered vehicles. But this was supposition, rather than proven fact.

…

San José's ATN study was funded with VTA Measure A funds, which enabled the City to conduct its analysis, but restricted its scope. The City could only consider an ATN configuration that linked the Airport to two proximate transit stations.

The City's Project team included Arup North America Ltd., a global planning and engineering consultancy, and The Aerospace Corporation, which operates a Congressionally-authorized Federally Funded Research and Development Center that provides objective technical and scientific research and programmatic advisory services to the federal government and other public agencies. **Arup was responsible for** transportation planning activities such as demand and revenue estimation, detailed infrastructure alignment, **cost estimates, and the business case analysis and risk assessment.**

…

Aerospace concluded that, technically, the City could probably build an ATN at the Airport that would nominally meet most of its needs. Passenger volume is fairly low within and to the Airport. The exception is between the Airport's Terminal A and the rental car facility opposite Terminal B. Long-term projections for passenger travel between these two points are quite high during peak periods, higher than it appeared from the information provided that current ATN designs would be able to support. Aerospace devised a solution that would allow the system to meet the Airport's inter-terminal travel requirements. In fact, the solution may provide service comparable to a conventional APM while offering greater flexibility. But, it must still be verified conceptually and physically.

Aerospace's high capacity solution was integrated into the 6.4 linear-mile 10-station ATN concept the City developed, based on input from the Project team as well as the Project's prime stakeholders – VTA and the Airport. Attached is a map of the proposed ATN system and project renderings. The system connects the Airport to rail lines on either side of the Airport as well as terminals, a rental car center, and parking facilities within the Airport. **Despite the inclusion of sizable risk contingencies to account for unknown aspects of the technology, Arup concluded that the estimated capital cost of the Airport ATN Project would be less than the APM system the City and VTA had considered.**

…

None of the issues raised by the City's ATN Team are insurmountable. Further information from ATN developers could also alter some of the Team's conclusions.

The City's decision to conduct this study has gained international interest. The report highlights some of the issues that must be resolved or solutions that must be verified to realize the potential of this unique and intriguing form of transit service. Should the City wish to continue to pursue construction of an ATN system, there are strategies it could take, at minimal risk and in partnership with other public agencies in the U.S. and abroad, to achieve that goal.

…

Regulatory Issues: The regulatory effort that would be associated with qualifying ATNs for use within the State is difficult to estimate and predict. The California Public Utilities Commission (CPUC) will have regulatory authority over an ATN in San José. Other authorities such as Cal-OSHA would likely also have a significant role. The CPUC's standard certification process was developed for the safe design, construction and operation of conventional systems. The initial qualification of a new technology like ATNs would require a different type of effort, similar to the 1960's certification of BART's automatic train control system. No standard process exists for an effort of this type. It would almost certainly mean that the CPUC will need to author an entirely new set of regulations or "General Order". The General Order would be based on extensive interactions with industry, including physical demonstrations of safe operations over a wide range of operating conditions and performance levels in a process similar to what appears to be taking place overseas.

The level of technical uncertainty and unknowns illuminated by Aerospace also had implications for the business case.

Estimated Costs: Arup had to estimate the cost of building and operating an ATN when such systems have not yet been standardized, without the benefit of knowing what the CPUC would require, and where there are few operating examples from which to extrapolate. Consequently, its cost estimates for the Project are necessarily preliminary. **Using industry best practices, Arup developed conservative basecost estimates and added a sizeable risk contingency (134% of the base cost) to account for the as yet unknown factors. Arup has estimated that it would cost approximately $758 million (in 2012 dollars) to construct the ATN system, versus $967 million for the APM (escalated to 2012 dollars and including a 40% risk contingency, as APM technology is proven and has regulatory approval in the U.S.).**

Private Financing: Arup's assessment is that private financers would be willing to enter into a public-private partnership to fund the construction, operation, or maintenance of the project. But this will not occur until ATN developers can demonstrate that the technology can effectively meet the City's project requirements and reduce the cost and schedule risks identified to a level deemed bankable by the market.

…

Conclusion

Given the level of technical and regulatory uncertainty, it would be too risky for the City to proceed immediately to a conventional design/build process to build the Airport ATN. More information is needed … practical considerations recommend against moving forward with the Airport project in the short term. **The two primary concerns are the Airport's financial situation and the anticipated decade or more that may be required before BART is extended to downtown San José and Santa Clara.**

…

Staff concurs with its experts that ATN technology appears to have merit and is worth continued pursuit. If San José is interested in doing so, there are steps the City could take, at minimal risk, to continue to exercise national leadership, advance ATN technology, encourage the industry's development, and ultimately build a system that furthers its transportation goals.

…

<u>Suggested Next Steps</u>

Staff recommends that the City defer active development of a San José ATN project and instead focus in the near-term on supporting overall ATN industry development by pursuing the following steps:

1. Share the findings of the City's study with others, particularly other public agencies.

2. Coordinate with the FTA, Swedish governmental agencies, and other key stakeholders to map out a collective path forward and to secure funding to support ATN development.

3. **Initiate a dialogue with ATN developers and the CPUC regarding establishing a process to develop regulations for building ATN systems in California.**

http://www.sanjoseca.gov/DocumentCenter/View/20662

City of San José DOT
San José International Airport Automated Transit Network Feasibility Study
Final Report, 4-05; Issue | October 19, 2012

[page 48]

6.1 Capital Costs

Arup developed a capital cost estimate for the ATN system as input into the Preliminary Business Case summarized in Chapter 8 and **detailed in Appendix E, Preliminary Business Case Report.** Costs are expressed in 2012 dollars. Arup classifies the cost estimate at a Level 5 Rough Order of Magnitude, meaning it is at the most conceptual and least detailed level of cost estimating. On this scale, Level 1 represents a detailed, construction-ready estimate with relatively low contingency while **Level 5 is the most conceptual level of estimate and includes the highest levels of contingency. The Feasibility Study is technology-neutral, analyzing feasibility on the basis of the widest track requirements, largest minimum turn radii, and heaviest vehicles. Tradeoffs have also been made in the alignment development process to favor larger turn radii to support higher operational speeds, with consequently higher costs.** In future phases of study and design, the cost estimate would be refined, and contingencies likely reduced, as more detail is made available. For example, if a vendor is chosen then the costs can be focused on a much more specific set of system requirements and technology characteristics.

The cost estimate reports costs for the three alignment segments described in Section 3.4.

The capital cost estimate is comprised of three primary elements: base costs; indirect costs and related elemental contingency; and categorical risk contingency.

The base capital cost components include the following: guideway (single-track, double-track, and triple-track); minor stations (parking lot, VTA, and Caltrain stations); major stations (terminal stations); a maintenance facility; general allowances for utility relocations and small subcontracted work; control system (proportion of base construction cost); and vehicles (based on assumed unit cost and fleet size).

Indirect costs and other additions include: contractor indirect costs; contractor overhead and profit; design engineering; project insurance; tax; bond; and an elemental risk contingency. The elemental risk contingency is intended to cover unexpected cost increases in labor, equipment, materials, design, sub-consultants, overhead, and/or profit.

Finally, categorical risks are included in the capital cost estimate. Categorical risks refer to external risks specific to a project, some of which can be quantified as more information about the project is gathered. Some categorical risks cannot be quantified. Examples that can be quantified over time include risks due to design (including emerging technological development), construction, operations, site conditions, and regulatory codes/standards. Examples of risks that cannot be quantified include political, legislative, and funding changes. The process used to identify and quantify categorical risks is described in the Preliminary Business Case in Section 8.4.3.

The ATN total capital cost estimate is reported in Table 14 by risk scenario and by segment. Percentile risk indicates the level of confidence in the estimated cost. The 30th percentile scenario reflects the view generally taken by construction builders and implies a 70% chance that the costs will be higher than the value presented. **The 80th percentile scenario reflects the view generally taken by the Federal Transit Administration (FTA) and implies a 20% chance that the costs will be higher than the value presented.** The 95th percentile scenario reflects the view generally taken by lenders and implies a 5% chance that the costs will be higher than the value presented.

Table 14: ATN Capital Cost Estimate

Cost Scenario (inclusive of Base Cost, Elemental Risk, and Categorical Risk)	Capital Cost by Segment (2012 $, Million)			Total Capital Cost (2012 $, Million)
	Segment 1	Segment 2	Segment 3	
Scenario 1: 30th Percentile	263	107	167	**537**
Scenario 2: 80th Percentile	371	152	235	**758**
Scenario 3: 95th Percentile	445	182	282	**909**

Source: Arup

Please see the Basis of Capex Estimate in Appendix C for more detail about the capital cost estimate.

When a risk multiplier of 2.34 is removed from $758M, the cost could be also be $323.9M (or less) for 6.4 miles of ATN, or $50M/mile.

Automated Guideway Transit Study

In March 2017, San José released a high level assessment of the viability of constructing an Automated Guideway Transit (AGT) system connecting the San Jose Norman Y. Mineta International Airport with Diridon Station and other nearby destinations . AGTs include ATNs as well as more conventional automated transit technologies, such as Automated People Movers and automated metro systems. The study was funded by the Department of Transportation and conducted by ARUP. It concluded, among other things, that 1) there is sufficient potential demand to justify the construction and operation of an AGT system between Diridon Station and the Airport; 2) an ATN would be the most appropriate AGT technology choice given the potential demand

and characteristics of the market identified in this study; and 3) that the capital cost-effectiveness of an ATN could be on par, or potentially better, than that of recently-built APM systems (e.g., Oakland Airport Connector).

Automated Guideway Transit Study Reports:

- Automated Guideway Report

Initial ATN Feasibility Study

In Oct 2012, San José completed a comprehensive analysis of the technical and financial feasibility of building an ATN linking nearby mass transit stations with the San Jose Norman Y. Mineta International Airport. The study, which was funded by the Santa Clara Valley Transportation Authority, concluded that ATN technology offers a lot of promise. But further development and testing is needed to confirm the technical and business cases for ATNs. The City is continuing to pursue opportunities to advance this technology and industry in Silicon Valley and the U.S.

Initial ATN Feasibility Study Reports:

- ATN Staff Memo
- ATN Report from **Aerospace** (17 MB)
- ATN Report from **Arup** (12 MB)
    - *Appendix A (18 MB)*
    - *Appendices B, C, D and E (5 MB)*

http://www.sanjoseca.gov/DocumentCenter/View/20663

Appendix C, Cost and Revenue Memos

C1 Rough Order of Magnitude Cost Estimate

C2 APM Cost Comparison Methodology Memo

C3 Alternative Revenue Sources Memo

C4 Potential Advertising Revenue Memo

1.7 Structure of Estimate

1.7.1 Single Track Guideway

Due to the high level cost estimate required it has been assumed that all guideway is to be on elevated structure, as there is an insignificant quantity of guideway at grade.

Substructure

- **4’ diameter drilled concrete piles, 50’ deep, with 295 pounds of rebar per cubic yard of concrete. Piles at 80’ centers.**

Superstructure

- **Reinforced 2’6” diameter concrete columns, 18’ high from ground level. Columns at 80’ centers;**
- **Reinforced concrete Crossheads, 4’ by 3’ by deck width of guideway;**
- Reinforced concrete elevated structure as per sketch provided as Attachment A; [5’ 9"-wide roadway with independent cars, not guideway-captured bogie and attached cab]
- **Arup developed a cost alternative for a steel supporting guideway with input from a specialized APM manufacturer, but this proved to be more expensive than the concrete option.**

…

1.7.10 **Vehicles**

Cost data has been gathered from similar projects around the world and a large range was discovered **from USD$63,000 to USD$200,000 per vehicle. A mean price of USD$130,000 was chosen** for the Capex estimate. A maximum fleet size of 300 vehicles has been assumed at buildout based on input from Aerospace Corporation. Vehicles are assumed to be purchased in batches by alignment segment.

Page 28: Main Worksheet – Build Alternative

10 GUIDEWAY & TRACK ELEMENTS = $103.7M (Guideway cost/mile = $16.2M)

20 Aerial station, stop, shelter, mall, terminal, platform: $38.9M for 10 stations or $6M/mile

30 Support Facilities = $8.9M or $1.4M/mile

40 SITEWORK & SPECIAL CONDITIONS = $21.8M or $3.4M/mile

Site Utilities, Utility Relocation = $5.1M

Site structures including retaining walls, sound walls = $5.3M

Pedestrian / bike access and accommodation, landscaping = $5.3M

Automobile, bus, van accessways including roads, parking lots = $5.3M

50 SYSTEMS = $31.8M

Construction Subtotal (10 – 50) = $204.7M or $32M/mile

70 VEHICLES

70.01 Light Rail vehicles: $130K each x 300 = $39M, or 47 vehicles/mile ($6M/mile)

80 PROFESSIONAL SERVICES (applies to Cats. 10-50) = $36.7M

Final Design = $32.0

Professional Liability and other Non-Construction Insurance = $4.7M

Subtotal (10 – 80) = $280.4

90 UNALLOCATED CONTINGENCY = $43.7

Subtotal (10 – 90) **$324.1M total project cost (before adjusting for risk factors) or $50.7M/mile:**
ESTIMATED COST SCENARIO 1 (30th @Risk Percentile) = $537M (or $84M/mile)

ESTIMATED COST SCENARIO 2 (80th @Risk Percentile) = $758M (or $118.5M/mile)

ESTIMATED COST SCENARIO 3 (95th @Risk Percentile) = $909M (or $142M/mile)

http://www.sanjoseca.gov/DocumentCenter/View/20663 Arup appendices B through E

Appendix E: Preliminary Business Case Report [page 67]

[page 102] 3.1.2 Development Base Costs

At this stage of the design development detail (i.e., < 2%), an allowance for the

Project development base costs has been assumed to be equal to 25% of

construction base costs. This is in line with industry benchmarks and the cost

accounts for the following pre-construction activities:

• Preliminary design engineering

• Right-of-way engineering

• Environmental documentation

• Procurement costs, such as bid documentation and award of contract

• Permit approvals

[page 106] 3.3 Risk Analysis

The objective of the risk analysis was to determine the total expected costs based on Project-specific knowledge.

Potential risk mitigation strategies for the Project are presented in Appendix A3.