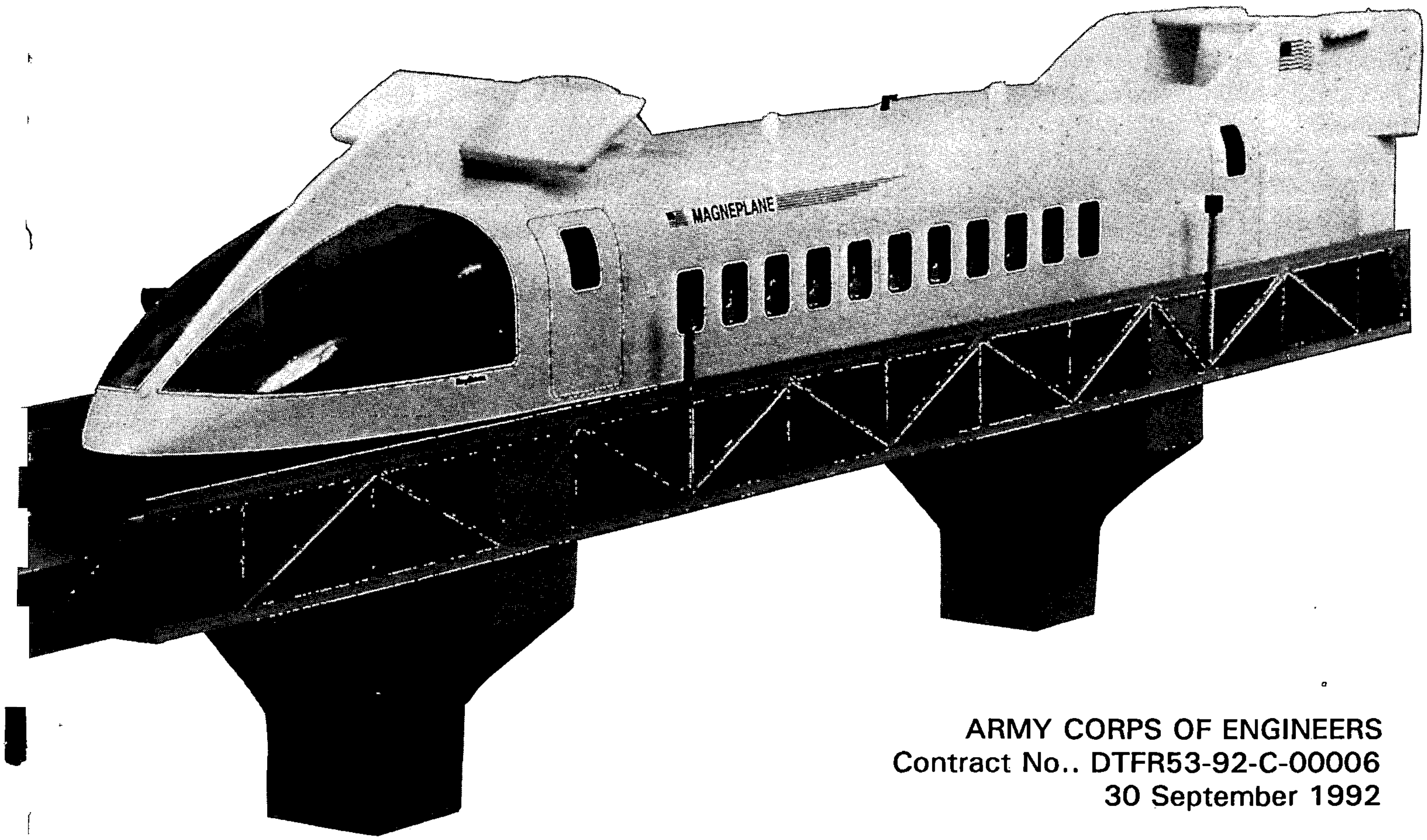
11 - Advanced Systems

Magneplane International • Massachusetts Institute of Technology
United Engineers and Constructors • Raytheon Equipment Division
Failure Analysis Associates • Bromwell & Carrier
Beech Aircraft Corporation • Process Systems International

SYSTEM CONCEPT DEFINITION REPORT
for the
NATIONAL MAGLEV INITIATIVE

Volume 6

RESPONSES TO C.O.E. COMMENTS
SUPPLEMENT A: BACKUP MATERIALS FOR MAGWAY FOUNDATIONS
SUPPLEMENT B: BACKUP MATERIALS FOR COSTS



ARMY CORPS OF ENGINEERS
Contract No.. DTFR53-92-C-00006
30 September 1992

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Jet Aviation Terminal, Hanscom Field West
Bedford, Massachusetts 01730
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INDEX TO VOLUMES

VOL.	*SECTIONS*
1	EXECUTIVE SUMMARY MAGLEV SYSTEM REQUIREMENTS MAGNEPLANE SYSTEM SPECIFICATIONS GLOSSARY
2	3.2. SYSTEM DESCRIPTION (VEHICLE, MAGWAY, and SYSTEMWIDE)
3	5.3.2. TRADEOFF ANALYSES
4	5.3.3. PARAMETRIC PERFORMANCE REPORT 5.3.4. ENERGY ANALYSIS 5.3.5. MAINTENANCE PLAN 5.3.6. MAGNETIC FIELD ANALYSIS 5.3.7. ADVANTAGES AND DISADVANTAGES
5	5.3.8. PRELIMINARY ENVIRONMENTAL REPORT 5.3.9. TEST PLAN 5.3.10. SAFETY PLAN 5.3.11. LIFE CYCLE COST REPORT 5.3.12. COST ESTIMATE FOR SYSTEM DEVELOPMENT 5.3.13. EXTERNAL BENEFITS
6	RESPONSES TO COE COMMENTS SUPPLEMENT A: BACKUP MATERIALS FOR MAGWAY FOUNDATIONS SUPPLEMENT B: BACKUP MATERIALS FOR COSTS
7	SUPPLEMENT C: BACKUP MATERIALS FOR MAGWAY STRUCTURE
8	SUPPLEMENT D: VECHICLE SPECIFICATION SUPPLEMENT E: LSM WINDINGS INDUCTANCE CALCULATIONS SUPPLEMENT F: VEHICLE DYNAMIC RESPONSE EQUATIONS SUPPLEMENT G: ROUTE ANALYSIS TOOLS SUPPLEMENT H: HEAVE DAMPING CAPABILITY ANALYSIS SUPPLEMENT I: BACKUP MATERIAL FOR CONTROL AND COMMUNICATION

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RESPONSES TO C.O.E. COMMENTS

CONTENTS

U.S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT: MAGLEV - Magneplane System Concept Definition, CN 5-85

- [ ] SITE DEV & GEO
- [ ] ENVIR PROT&UTIL
- [ ] ARCHITECTURAL
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- [ ] SAFETY
- [ ] ADV TECH
- [ ] ESTIMATING
- [ ] SPECIFICATIONS
- [ ] SYSTEMS ENG
- [ ] VALUE ENG
- [ ] OTHER

REVIEW TYPE: Prelim Report
DATE: 13 May 92
NAME: Richard Baker/jp/ED-ME/5-5181

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	General	Passenger egress between stations (such as with an emergency stop) has not been addressed. This must include handicapped passengers in wheelchairs. Correct.	UED-1 (A)
2.	Page 6	It does not seem feasible to have the superconducting magnets operating in areas where low speeds are expected since these areas will not have any levitation sheets. Verify.	MI-1 (N)
3.	Page 13 3.1.1.e	Exposure of animals (i.e., cattle, horses) to magnetic fields should be addressed.	MIT-1 (A)
4.	Page 48	Drawings in figure 27 are transposed both vertically and horizontally.	MI-2 (A)
5.	Page 99 25.783	Refers to pressurization of the "airplane". Correct.	BAC-1 (A)
6.	Page 107 25.869	Discusses "Oxygen Equipment Lines". Verify and correct.	BAC-2 (A)
7.	Page 108 25.963 25.954	Discusses "Fuel System" and "Fuel Tanks". Verify and correct.	BAC-3 (A)
8.	Page 109 25.1103	Clarify which operator (in the pilot compartment or in central control station) is to intervene in case of an emergency.	BAC-4 (A)
9.	Page 110 Figure 63	Figure 63 was omitted.	BAC-5 (A)

ACTION CODES:
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CEHND FORM 7 (Revised)
15 Apr 89

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U. S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

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PROJECT: MAGLEV - Magneplane System Concept Definition, CN 5-85

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- ☐ OTHER

REVIEW TYPE: Prelim Report
DATE: 13 May 92
NAME: Richard Baker/jp/ED-ME/5-5181

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10.	Page 117	Feed tube on the A-pad needs to be near the top of the pad due to wear.	BAC-6 (A)
11.	Page 122	A detailed aerodynamic design needs to be performed.	LIMJ-1 (N)

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U. S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT: CN 5-85 MAGLEV MAGNEPLANE INT., INT., CONCEPT DEFINITION

- ☐ SITE DEV & GEO
- ☐ ENVIR PROT&UTIL
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- ☐ ADV TECH
- ☐ ESTIMATING
- ☐ SPECIFICATIONS
- ☐ SYSTEMS ENG
- ☐ VALUE ENG
- ☐ OTHER

REVIEW: DRAFT
DATE: 22-5-92
TYPE
NAME: KEN SHAVER/ 5346/ ED-ME

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	P.111	The worse case stopping is not as stated. It would be a total loss of power and the vehicle slowing by aerodynamic drag until the high friction pads touched the guideway and then the combination would slow the vehicle. Recalculate the minimum headway based on this contingency.	MI-55 (N)
2.	P.11	Develop your formula Tb=2Th. The logic behind this formula is not transparent.	MI-3 (A)
3.	p.133	For this table on vehicle loads, add the load for battery charging.	FAA-1 (A)
4.		General Note: The power part of the report is very brief and not in sufficient detail to warrant comments at this time. More development is needed for the final report.	FAA-2 (A)

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CEHND FORM 7 (Revised)

4

DESIGN REVIEW COMMENTS

PROJECT ~~MAGLEV Magneplane SCD (CN5-85) S: 22 May 92~~

- ☐ SITE DEV & GEO TECH
- ☐ ENVIR PROT & UTIL
- ☐ ARCHITECTURAL
- XX STRUCTURAL
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- ☐ ADV TECH
- ☐ ESTIMATING
- ☐ SPECIFICATIONS
- ☐ SYSTEMS ENG
- ☐ VALUE ENG
- ☐ OTHER

REVIEW TYPE Draft

DATE 21 May 1992

NAME B. Hasse/lj/205-955-3934

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
		Review comments are provided on the attached MAGLEV Comment Form.	

ACTION CODES:
A — ACCEPTED/CONCUR
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CEHND FORM 7 (Revised)
15 Apr 89

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MAGLEV

PROJECT MAGNEPLANE DRAFT SCD REPORT (CN5-85)

- [ ] Site Development
- [ ] Architectural
- [x] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other

NAME: Pell BOB HASSE (205)955-3934
ORGANIZATION: CEHND-ED-CS
DATE: 22 MAY 1992

TEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	GENERAL	SI units must be used.	MI-4 (A)
2.	3.2.1.a.1	Figure 27 is inverted	MI-5 (A)
3.	3.2.1.b.7	Verify that LSM current capability increases more than the decrease in LSM power due to misalignment on order to correct for lower than design speed in a corner.	MIT-2 (A)
4.	Figure 64	This figure does not identify what units are used, also add a total weight column.	BAC-7 (A)
5.	3.2.1.e	Verify that the keel affect will allow enough free vehicle roll so that lateral accelerations will remain within acceptable ranges when passing a curve at other than design speeds.	LLMJ-2 (A)
6.	3.2.2.a.2	Verify that the moving live loads due to the vehicle include lateral accelerations and increased "downward" load due to a corner or a vertical curve.	UED-2 (A)
7.	3.2.2.a	More detail is required to evaluate technical feasibility, including; elevation views, super-elevated sections, dimensions, location and types of reinforcement, details of span to pier connection, etc..	UED-3 (A/N)
8.	3.2.2.a	Discuss in detail how spans, both the aluminum levitation plates and the main girder or truss, are mounted, aligned, and adjusted.	UED-4 (A)
9.	3.2.2.c	Verify that the allowable alignment tolerances given match those used in Section 3.2.1.e Vehicle Dynamics.	UED-5 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE DRAFT SCD REPORT (CN5-85)

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- [ ] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other

NAME: BOB RASSE (205)955-3934
ORGANIZATION: CEHND-ED-CS
DATE: 22 MAY 1992

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10.	3.2.2.d	Discuss the switch cycle times impact on headway including the 5 minute recycle time.	UED-6 (A)
11.	3.2.2.e	The second bullet on the top of page 213 contains an apparent misprint.	UED-7 (A)
12.	3.2.2.e	Verify that Safety/Emergency situations will not require a ground access road making this construction technique unnecessary.	UED-8 (N)
13.	3.2.2.g	The dynamic interaction between the high speed vehicle and the guideway is an important consideration in both ride quality and guideway design and must be investigated and discussed.	LLMJ-4 (A)
14.	3.2.2.i.4	Investigate the human factors and the aesthetics involved in fully enclosing the guideway in a chain link fence. Also, further investigation into the acoustic noise due to induced air velocity is required.	RRH-1 (A)
15.	3.2.2.j.1	Discuss EM field shielding requirements in stations and maintenance facilities.	MIT-3 (A)
16.	3.2.3.1	Include a discussion of EM health effects, perceived safety, and aesthetics in the human factors considerations.	MIT-4 (A)
17.	5.3.2.2.a	Include structural considerations in levitation sheet thickness tradeoffs.	UED-9 (A)
18.	DWGS	SI units must be used.	MI-6 (A)

ACTION CODES:
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PROJECT MAGNEPLANE DRAFT SCD REPORT (CN5-85)

☐ Site Development	☐ Electrical	☐ Safety	☐ Mechanical
☐ Architectural	☐ Instr. & Controls	☐ Advance Tech.	☐ Aerodynamics
☒ Structural	☐ Magnetics	☐ Estimating	☐ Other

NAME: BOB HASSE (205)955-3934
ORGANIZATION: CEHND-ED-CS
DATE: 22 MAY 1992

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
19.	DWGS	Include more detailed drawings of the guideway, including; span to pier connection, aluminum sheet to girder connection, guideway elevation and plan views, etc..	UED-10 (A/N)
20.	DWGS	Drawings should include dimensions, section sizes, and material properties.	UED-11 (A/N)
21.	SUP. DOC.	Levitation plate calculations must take into account that the vehicle may have any speed in a corner.	UED-12 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT Magneplane Systems Concept Draft Report (CN 5-85, S:22 May 92)

~~Geotech~~ Site Development | Electrical | Safety | Mechanical
Architectural | Instr. & Controls | Advance Tech. | Aerodynamics
Structural | Magnetics | Estimating | Other

NAME: A. Dohrman/bir/3278
ORGANIZATION: CEHND-ED-CS
DATE: 20 May 1992

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
		DRAWINGS	
1.	Sheet S-3	a. The drawing is not clear on the configuration of the switch. A plan view of the last 10 to 15 meters of the switch and first 5 meters of the branch line, in particular the horizontal spacing of the hydraulic cylinders and the location of the extendable sections, would be helpful. b. Indicate how the various sections and details relate to each other (show on the plan or other views where each section is cut).	UED-13 (A)
		TEXT	
2.	Page 111, Para 3.2.1.d.1	Describe the source of the equation given relating braking time to headway.	MI-7 (A)
3.	Page 180, Para 3.2.2.a.2	Verify that lateral loads due to vehicles negotiating horizontal curves have been considered.	UED-14 (A)
4.	Page 188, Para 3.2.2.a.5.2	The soil bearing assumed of 5 KSF (250 kN/m^2) at a depth of 2.5 feet (0.75 m) is extremely high for a sand with N=10. A more realistic figure for this type of soil would be 100 kN/m^2. Alternately, the allowable bearing and other parameters provided for the Severe Segment Test could be used.	BCI-2 (A)

ACTION CODES:
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MAGLEV

PROJECT ~~Magneplane Systems Concept Draft Report (CN 5-85, S:20~~ May 92)

X ~~Geotech~~

] Site Development ☐ Electrical ☐ Safety ☐ Mechanical
] Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
] Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: A. Dohrman/bjr/3278
ORGANIZATION: CEHND-ED-CS
DATE: 20 May 1992

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
5.	Page 239, Para 3.2.2.i.4	Verify that the effect of fully enclosing the guideway on emergency egress has been considered.	RRH-1 (A)
6.	Page 242, Para 3.2.2.k	Document assumptions and rationale concerning length and spacing of rock bolts/anchors.	UED-16 (A)

ACTION CODES:
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2 2

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PROJECT MAGNEPLANE SCD (5-85, 22 May 92)

- [x] Site Development
- [ ] Architectural
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- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ______

NAME: Darby
ORGANIZATION: USAEDH, ED-CS
DATE: 18 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	Fig 64, pg 112	State units for tabular data.	BAC-8 (A)
2	3.2.1.d.1, pg 111	The formula provided to determine the time required to brake to a complete stop does not include response time. Revise appropriately.	MI-8 (A)
3	3.2.1.k.15 pg 158	Verify that a Global Positioning System (GPS) provides a response time interval that could allow it to serve as a backup for guideway position sensors. Discuss the provisions required to utilize GPS within the framework of a maglev system.	RRH-2 (A)
4	3.2.2.c.1, pg 199	Verify all °C to °F conversions stated in this section.	UED-17 (A)
5	3.2.2.d.1, pg 201	The orientation of the linear synchronous motor (LSM) in the guideway trough varies from the lowest point in the trough for straight runs to some angular offset from this low point for curved sections. The switch A operation proposed in Figure 119 rotates a straight run articulated section to a point of tangency with a curved section. It appears that at this point of tangency a mismatch would occur for the LSM in the guideway trough. Additionally, the crossover orientation given in Figures 121 and 123 would allow the LSM windings to match at the point of tangency but would not allow the propulsion module in the "banking" maglev vehicle to coincide with the LSM, since the LSM would always be oriented in the low point of the trough. Address these concerns.	UED-18 (N)

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MAGLEV

PROJECT MAGNEPLANE SCD (5-85, 22 May 92

[X] Site Development [ ] Electrical [ ] Safety [ ] Mechanical
[ ] Architectural [ ] Instr. & Controls [ ] Advance Tech. [ ] Aerodynamics
[ ] Structural [ ] Magnetics [ ] Estimating [ ] Other

NAME: Darby
ORGANIZATION: USAEDH, ED-CS
DATE: 18 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
6	5.3.7.1.g, pg 392	As stated in this section, "the guideway trough is open at the center, where the propulsion windings are located, and therefore sheds water, snow and ice". Given this open configuration at the base of the guideway trough, provide a discussion of the noise this configuration would generate from a passing vehicle. Provide this discussion in section 5.3.8.2, page 396.	MI-58 (A)
7	5.3.7.1.g, pg 392	Given that the location of the propulsion windings will provide an opening for shedding water,snow and ice, what will the effectiveness for drainage of the opening be when the propulsion windings are rotated out of the low point of the guideway trough, as in a horizontal curve?	UED-19 (A)
8	3.2.2.d.1, Fig 122, pg 205	As noted in the crossover geometry presented, a gap of 1.11 meters occurs between guideway switches in the crossover position. This gap is closed by the use of the mechanical switch extendible tongue shown in Figure 127. What is the effect on the operation of the vehicle given a section 1.11 meters long void of LSM windings?	UED-20 (A)
9	3.2.1.d, pg 111	Clarify the following concerns relative to the braking pads. What effect would contact between the emergency brake friction pads and the LSM windings be resulting from emergency braking in a horizontal curve? Similarly, what is the effectiveness of the anti-friction braking pad when oriented over the LSM windings? Would contact occur between the anti-friction pad and the windings when braking in a horizontal curve? What is the expected result from this contact?	MI-59 (A)

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U. S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT Maglev Magneplane Sys Concept Def #5-85

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REVIEW TYPE: Prelim Rpt
DATE: 21 May 92
NAME: Bill Chaffin/205-955-4173

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	Section 3.1	This section of the executive summary just refers to other section. If information is not at least present in condensed form, delete the section.	MI-9 (N)
2.	Section 3.2.1.C.3	The need for fuel tanks and fuel tank protection is not clear. What type of fuel is anticipated and for what purpose?	BAC-9 (A)
3.	Section 3.2.1.C.1	Under human factors considerations, state requirements for sizing of seats, spacing between seats, and headroom in vehicle.	BAC-10 (A)
4.	Section 3.2.2	The guideway concept has changed from the previous concept and is now shaped like a trough. This would appear to increase the likelihood of fouling due to foreign objects on the guideway. How is this being addressed?	MI-60 (A)
5.	Section 5.3.10.0.3	Fouling of the guideway by foreign objects should be a critical safety item.	FAA-3 (A)

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NAME: J. Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	p. 1	Goals 2 and 8 are not part of the scope for this contract.	MI-10 (A)
2.	p. 5ff	The customary abbreviation for force due to gravity is "g". ~~"Gee" is used to get a mule to turn right.~~	MI-11 (N)
3.	p. 7 Sub-optimal Curve Performance and Low Speed Curve Performance	Explain why this isn't a major concept shortcoming.	MI-12 (A)
4.	p. 9	Air bearings and air lubrication per se does not appear to be proprietary.	MI-13 (A)
5.	p. 12 para 3.1.1b	25,000 seats per hour is eqivalent to 7 lanes of interstate highway at 2000 cars per hour and 1.7 passenger per car or 4 737's per minute (requiring 4 active takeoff runways). This capacity is overkill for competition with auto and air modes.	MI-14 (N)
6.	p. 18 para 3.1.3.a	Address SOW supplemental wind requirements (30 mph, 50 mph, 75 mph gust).	UED-21 (A)
7.	Fig. 50	Where is this figure referenced in the text?	MI-15 (A)
8.	p. 89 condition 2	Where is figure [FAA-321-5]?	MI-16 (A)
9.	p. 90 condition 2	Which strategy will you use?	BAC-11 (N)

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PROJECT Magnaplane System Concept Definition

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☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: John Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10.	p. 97ff	FAR's may be excessively restrictive. Discuss other possible criteria and advantages/disadvantages.	BAC-12 (A)
11.	P. 111 para 3.2.1.c.8	Balance is not discussed.	BAC-13 (A)
12.	p. 111 para 3.2.1.d.1	Discuss other headway considerations such as switch operation and transit time, use of non-emergency deceleration rates, passenger warning times (for high braking rates) etc., that effect headways. These considerations will mandate larger headways for some portions of the route and some operational modes. Your 0.65g rate is inconsistent with the 0.45-0.6g given in para 3.2.1.d.2, which further implies a larger headway.	RMB-1 (A)
13.	p. 114 para 3.2.1.d.1	Inconsistent with para 3.21.c.1 which describes pneumatic strut skid actuators.	BAC-14 (A)
14.	p. 118 para 3.2.1.e	At 134 m/s, is your minimum radius 4 km or 2.5 km?	MI-17 (A)
15.	p. 120	Figures 69 and 70 should appear immediately after, and in the order, referenced.	MI-18 (A)
16.	p. 128 para 3.2.1.f.2	How large are the expected trim roll angles and lateral offsets? (Figure 75?) How does the stability augmentation system "know" not to trim these out?	LLMJ-5 (A)
17.	p. 128 para 3.2.1.f.3	Show that these forces and moments are sufficient for expected disturbances.	LLMJ-6 (A)

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NAME: John Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
18.	p. 130 para 3	How were the pitch, roll and yaw rates used?	LLMJ-7 (A)
19.	p. 139 para 3.2.1.i	Can you show that the 1 and 5 gauss SOW requirements won't disqualify the Magnaplane concept?	MIT-5 (A)
20.	p. 143 para 3.2.1.j.1	What are the passenger electromagnetic field implications of this power pickup scheme (200 Hz fields directly under the passenger areas)?	FAA-4 (A)
21.	p. 146 para 1	Clarify the implications of a third failure (rewrite the sentence mentioning a third failure).	RMB-4 (A)
22.	p. 154 para 3.2.1.k.6	Is this analog, after-the-fact velocity and position computation responsive enough to ensure timely commands to the wayside controllers? What is the control cycle time (passing two transmitters, computation, communication, and system response) and the associated spatial offset and uncertainty.	RMB-5 (A)
23.	p. 156 para 2	Inconsistent with para 3.2.1.f.2, which says these crosswind perturbations will not be corrected.	RMB-6 (A)
24.	p. 156 para 3.2.1.k.10	Yaw transducers give relative wind direction, but not guideway alignment information. What purpose does this information serve?	RMB-7 (A)
25.	p. 157 para 3.2.1.k.11	The 15 cm guideway clearance requires more demanding translational control than for aircraft, by several orders of magnitude. Where do you demonstrate this control authority?	RMB-8 (A)
26.	p. 157 para 3.2.1.k.13	What is state-of-the-art deicing equipment? Is it included in the power and weight budgets?	RMB-9 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT Magneplane System Concept Definition

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☒ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other

NAME: John Potter
ORGANIZATION: U.S. Army Corps of Engr
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
27.	p. 158 para 3.2.1.k.14	200 Hz is inconsistent with computations from 11 meter transmitter stations, which give position information at less than 134/11=12 Hz.	RMB-10 (N)
28.	p. 158 para 3.2.1.k.14	Are analog control lines shielded against EMI?	RMB-11 (A)
29.	p. 158 para 3.2.1.k.15	See item 22.	RMB-5 (A)
30.	p. 159 para 3.2.1.k.17	For external (RF), communications failures how can the wayside controller "know" to take action to allow the vehicle to invoke emergency braking operations.	RMB-12 (A)
31.	p. 161 Figure 90	This table is based on ±9.4 degrees, but should use ±9.1 degrees.	LLMJ-8 (A)
32.	p. 167	But Figure 95 shows that 2 vehicle consists are more economical!	MI-19 (N)
33.	p. 171 para 3.2.1.m.9	See item 13.	BAC-14 (A)
34.	p. 181 para 3.2.2.a.3	Single span computations are inconsistent with para 3.2.2.a.1	UED-22 (A)
35.	p. 188 para 3.2.2.a.5.2	These criteria are inconsistent with the SOW.	BCI-1 (N)

ACTION CODES:
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MAGLEV

PROJECT Magneplane System Concept Definition

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NAME: John Potter
ORGANIZATION: U.S. Army Corps of Engi
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
36.	p. 198 last para	It's a little late to discover that the guideway sheet used for the entire system design and costing must be thicker. How much thicker must it be? What are the implications for system cost?	UED-24 (A)
37.	p. 201 para 3.2.2.d.1	Address centerline length adjustments required for closure on crossovers.	UED-25 (A/N)
38.	p. 211 para 3.2.2.d.3	This switch scheme requires a mainline headway of 36 sec plus GCS delay, at 134 m/s. Inconsistent with para 3.2.1.d.1 even with 0.65g deceleration.	UED-26 (N)
39.	p. 216 Fig 129	Move to correct location!	MI-20 (A)
40.	p. 226 Layout	Correctly order figures 135, 138, etc.	MI-21 (A)
41.	p. 239 para 3.2.2.i.4	This noise treatment is inadequate.	LLMJ-9 (A)
42.	p. 245 para 3.2.2k	How large should tunnel be?	UED-27 (A)
43.	p. 252A para 3.2.3.a.2	Your GCS must be more automated than on ATC. A short headways, there's no time for human recognition, decision, and intervention.	RRH-3 (A)
44.	p. 283	Figure 166 is not referenced in the text between figures 165 and 167.	MI-22 (A)

ACTION CODES:
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MAGLEV

PROJECT Magneplane System Concept Definition

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [X] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ______

NAME: John Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
45.	p. 293 para 3.2.3.a.7.6	f and P are important at this stage of concept development. Show an estimate, at least.	RRH-4 (A)
46.	p. 297 GPS	Will GPS provide timely location data for vehicle control? Is response time included in headway calculations?	RRH-5 (A)
47.	p. 299 para 3.2.3.d.1	It's time you addressed this issue.	UED-28 (A)
48.	p. 299 para 3.2.3.d.2	See Item 47.	UED-29 (A)
49.	p. 299 para 3.2.3.d.3	See Item 47.	UED-30 (A)
50.	p. 299 para 3.2.3.d.4	This section doesn't say anything.	UED-31 (A)
51.	p. 300 para 3.2.3.d.5	When will this section be completed?	UED-32 (A)
52.	p. 300 para 3.2.3.d.6	See Item 51.	UED-33 (A)

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MAGLEV

PROJECT Magneplane System Concept Definition

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☒ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: John Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
53.	p. 302 para 3.2.3.f	See Item 47	MI-56 (A)
54.	p. 302 para 3.2.3.g	The system described is extremely complicated. What is the system reliability.	RMB-13 (A)
55.	p. 303 para 3.2.3.g.1	What is the effective reaction time for this cycle (including the humans in the loop)?	RMB-14 (A)
56.	p. 312 para 3.2.3.g.8	6 MVA for the 140 pass vehicle is inconsistent with Fig. 53 (8.2 MW), plus hotel power, etc.	FAA-5 (A)
57.	p. 314 para 3.2.3.h	See Item 54.	MI-61 (A)
58.	p. 314 para 3.2.3.i.4.b	"Selected areas" inconsistent with para 3.2.2.i.3.	MI-57 (A)
59.	p. 318 para 3.2.2.J.3	If slots are fixed and each vehicle must switch, then 2 blocks between vehicles must remain vacant and the real headway is 60 sec.	RMB-15 (A)
60.	p. 318 para 3.2.3.j.3	If slots are globally controlled, why use a smart vehicle?	RMB-16 (A)

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NAME: John Potter
ORGANIZATION: U.S. Army Corps of Engi
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
61.	p. 320 para 3.2.3.j.3	This block system can't restart vehicles after emergency stopping.	RMB-17 (A)
62.	P. 323 para 3.2.3.j.7	What are the marketing implications (for the passenger) of dynamic scheduling? What is the maximum wait or minimum load for low-demand station pairs?	MI-23 (A)
63.	p. 324 para 3.2.3.1k	Address baggage	BAC-15 (A)
64.	p. 325 para 3.2.3.el	13 MVA inconsistent with previous requirements. See Item 56.	FAA-6 (A)
65.	p. 330 para 5.3.2.1.c.1.3	Hasn't this option been overtaken by selection of the 140 passenger baseline vehicle?	MI-24 (N)
66.	p. 331 para 5.3.2.1.c.2	Operational capacity will be a lot less.	MI-25 (N)
67.	p. 331 para 5.3.2.1.c.2	6.5 m/sec^2 is inconsistent with braking performance. See Item 38.	MI-26 (A)
68.	p. 339 para 5.3.2.2.b	Address phases and segmentation.	FAA-7 (A)

ACTION CODES:
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☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ____

NAME: John Potter
ORGANIZATION: U.S. Army Corps of Eng
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
69.	p. 339 para 5.3.2.2.c	Address block length.	FAA-8 (A)
70.	p. 358 para 5.3.2.2.f.1	Costs should be in \$/m or \$/km.	MI-27 (A)
71.	p. 368 para 5.3.2.2.h	1-1.5% total lateral force implies a very long switch (on the order of 1 km.	MIT-13 (A)
72.	p. 371 para 5.3.2.3.b	What is figure MJF 10?	MI-28 (A)
73.	p. 371 para 5.3.2.3.b	Is active magnetic damping feasible from a power standpoint?	FAA-9 (A)
74.	p. 400 para 5.3.8.5	Fill in table.	UED-34 (A)
75.	p. 400	Where is section on energy impact?	UED-35 (A)
76.	p. 409 para 5.3.10.3	Address loss of levitation.	FAA-10 (A)
77.	p. 410 para 5.3.10.6	Address fire.	FAA-11 (A)

ACTION CODES:
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MAGLEV

PROJECT Magneplane System Concept Definition

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
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NAME: John Potter
ORGANIZATION: U.S. Army Corps of Engrs
DATE: 15 May 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
78.	p. 410 para 5.3.10.7	Address Evacuation.	FAA-12 (A)
79.	p. 411 para 5.3.10.8	Address levitation/guidance magnet failure.	FAA-13 (A)
80.	p. 413 para 5.3.11	Cost estimates should be available by now!	UED-36 (A)
81.	p. 416 para 5.3.11.4.1	Replace "levelized" with "annualized" to follow engineering economics convention.	UED-37 (A)
82.	p. 418 para 5.3.13.a	This requirement for power production is a major disadvantage!	MI-29 (N)
83.	p. 419 para 5.3.13.c	Convenient, long, maglev commutes help road congestion, but encourage urban sprawl.	MI-30 (N)
84.	p. 420 para 5.3.13.c	Mobility (in and of itself) is not sufficient to "save inner cities."	MI-31 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE SCD - Draft Report

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: Raymond Wlodyka
ORGANIZATION: VNTSC/DTS-73
DATE: 5-22-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	Overall	The report indicates that Magneplane has given attention to most of the statement of work requirement, however there are many instances where coverage is sketchy or not included. Some of these items, e.g. LSM winding data, power distribution feeder cable data, will impact the cost estimates, and Magneplane should provide a schedule for when these items will be completed. The same comment applies for trade-off analyses which are still incomplete.	MI-32 (A)
2		Is the vehicle concept in full compliance with the Americans with Disabilities Act?	BAC-16 (A)
3		The concept of air bearings is interesting, what is the confidence level that Magneplane will adopt it?	MI-65 (A)
4	Page 80	Where does $p=\pi z$ come from?	FAA-14 (A)
5	Page 95	The use of a fuel fired APU is in conflict with the system requirements given in RFP section 3.1.2.e.	MI-33 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE SCD - Draft Report

☐ Site Development ☐ Checklist ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: Raymond Wlodyka
ORGANIZATION: VNTSC/DTS-73
DATE: 5-22-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
6	Page 111	0.65g exceeds the 0.2g recommended in the RFP section 3.1.2.b. Magneplane should consider the effects on passengers of stopping at such high rates. They should address RFP goals and requirements, e.g given the RFP recommended brake rates, can the system as presented meet the capacity goal specified in 3.1.2.a. What are deceleration rates when propulsion system power is not available to compensate for aerodynamic and/or magnetic drag?	MI-34 (A)
7	Page 111	Given the high magnetic drag of the concept, how will brake rate be controlled in the event of wayside propulsion system failure?	MI-35 (A)
8	Page 143	Is there a schedule for completing the inductive pick-up analysis? This analysis is critical because it will determine if an APU is required.	FAA-15 (A)
9	Page 153	Please explain what is meant by "2 fault operate, 3 fault safe performance".	RMB-4 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE SCD - Draft Report

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other

NAME: Raymond Wlodyka
ORGANIZATION: VNTSC/DTS-73
DATE: 5-22-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10	Page 220	Note the conditions that apply to the table in figure 132, e.g. per km per phase. From this table a maximum phase voltage of 19.7 kVac is indicated. This conflicts with the 17 kV mentioned on page 227.	FAA-16 (N)
11	Page 22	Has Magneplane given consideration to controlling power factor by controlling motor excitation?	FAA-17 (A)
12	Page 331	The levitation gap of 20 cm conflicts with the 25 cm gap mentioned earlier in the report.	MI-36 (N)
13	Page 405	Because wayside power is subject to loss due to power outages not related to the system, the wayside power system should not be safety related.	FAA-18 (N)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT Magneplane International

- ☐ Site Development
- ☐ Architectural
- ☒ Structural
- ☒ Electrical
- ☒ Instr. & Controls
- ☐ Magnetics
- ☒ Safety
- ☐ Advance Tech.
- ☒ Estimating
- ☒ Mechanical
- ☒ Aerodynamics
- ☐ Other ____________

NAME: S. S. Chen
ORGANIZATION: ANL
DATE: 5/20/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
Executive Summary		This draft appears to have been put together in a rush. Many components are not studied adequately. ~~This is probably due to the limited time available. The final report is expected to be improved significantly.~~	
	Require-ments	How should US develop the best maglev? Some remarks can be provided to explain why magneplane is a better choice.	MI-37 (A)
		What ride quality criterion is used to achieve the goal?	
		Is maglev to provide transportation for trips less than 400 miles only? Isn't that too short?	
		Do we really need maglev at shopping malls? Why?	
		The economic issue is not sufficiently discussed. How do we know magneplane should be the US choice?	
	Description	What will happen if the vehicle is not running at the design speed?	MI-38 (A)
	Issues	How can you determine that air-lubricated pneumatic pads are better than wheels at this stage?	MI-39 (A)
	Figure 2	No scale is given. It is not clear.	MI-40 (A)
Bogies	3.2.1.a.1.1	Using two levitation coil modules appears to be a good choice to reduce stray field effects.	MIT-6 (A)
Coil	3.2.1.a.1.2	It will be helpful to give the name of the computer code used in magnetic field calculations.	MIT-7 (A)
		Has the restoring force been calculated? A curve should be provided to show the restoring force as a function of vehicle displacement.	
Module	3.2.1.a.1.3	Do you have any plan to develop two different lift modules for the 140 and 45 passenger vehicles? Using the same lift modules for two different vehicles appears not to be the best choice.	MIT-8 (N)
		ACTION CODES: A–ACCEPTED/CONCUR N–NON-CONCUR W–WITHDRAWN	

MAGLEV

PROJECT Magneplane International

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NAME: S. S. Chen
ORGANIZATION: ANL
DATE: 5/20/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
Design	3.2.1.a.1.4	What finite element code was used for Figs. 23, 24, 25, and 26? Those figures can be explained in more detail and the scale should be given. Figure 27 is upside down.	MIT-9 (A)
Control	3.2.1.a.3	The rigid body motions of the vehicle are controlled. Has the flexibility of the vehicle been studied?	LLMJ-10 (A)
		The passive aerodynamic damping is considered to be small. What is the basis of this conclusion. Please give the reference. Is it possible to have negative aerodynamic damping in some specific conditions?	
		What is the best control law for the magneplane? What detailed information is available?	
		The lowest natural frequency of the vehicle bending modes is to be higher than 5 Hz. What is the basis to set this limit?	
Levitation	3.2.1.b.6.1	Provide some references or the theoretical basis to generate Fig. 55.	FAA-19 (A)
Braking	3.2.1.d.1	The unit is not given in Figure 64.	MI-62 (A)
Suspension	3.2.1.h	How do you calculate the passive aerodynamic damping given in Fig. 80? Do you have any experimental data?	LLMJ-11 (A)
		How reliable are the damping factors given in Fig. 81?	
IFPC Architecture	3.2.1.k.2	All aerodynamic control surface actuators are to be state-of-the-art designs developed under military programs. Are they reliable for maglev?	RMB-19 (A)

ACTION CODES:
A – ACCEPTED/CONCUR N – NON-CONCUR W – WITHDRAWN

MAGLEV

PROJECT Magneplane International

☐ Site Development ☒ Electrical ☒ Safety ☒ Mechanical
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NAME: S. S. Chen
ORGANIZATION: ANL
DATE: 5/20/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
Detection	3.2.1.k.5	How reliable are the sensors to be used?	RMB-19 (A)
Stabilization	3.2.1.k.8	Are the magneplanes stable without active control? This has not been addressed in the report. What kind of vehicle stability study has been performed?	RMB-20 (A)
Dynamics	3.2.1.el	Describe in more detail on the vehicle dynamics: • Do you consider active damping or negative damping? • Do you study coupled vehicle/guideway interaction? • How do you characterize guideway imperfection? • Do you have any data on motion-dependent magnetic and aerodynamic forces? • In addition to Fig. 93A, do you have any other results on vehicle responses? • What is the power requirement to achieve vehicle stability? • Without further study, is it possible to make some conclusions on the stability of magneplane? • Vehicle dynamics appears to have not been studied adequately. Are there any plans to perform further investigations?	LLMJ-12 (A)
Friction Pad	3.2.1.m.9.c	It is nice to provide the estimated cost for friction pad. It would be nice if the same approach could be applied to all other components; i.e., cost estimates for other components should be given.	MI-41 (A)
Design	3.2.2.a.2	• E is not defined. • What is the basis for the loading criteria? • Why are the dynamic loads not included at all?	UED-38 (A)
Spans	3.2.2.a.3	How is the dynamic load factor obtained? What kind of analysis has been performed to get the factor of 1.20? Are the allowable stress levels based on fatigue only? How about the dynamic loading resulting from abnormal conditions?	UED-39 (A)

ACTION CODES:
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MAGLEV

PROJECT Magneplane International

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- ☒ Structural
- ☒ Electrical
- ☒ Instr. & Controls
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- ☐ Other

NAME: S. S. Chen
ORGANIZATION: ANL
DATE: 5/20/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
Pile	3.2.2.a.5.5	Had the inclined piles been considered?	BCI-3 (A)
Beams	3.2.2.b.2	The box beams were designed to withstand vehicle loads. How about cross wind?	UED-41 (A)
		Are the box beams really continuous?	
		The maximum dynamic deflection is limited to be 1/2000 of span length. In 3.2.2.a.2 (Design Criteria). It is set to be 1/1150 of span length (0.02m for a 23m span). Why is there the difference?	
		What is d? The last sentence of this item on page 198 is not clear.	
Settle-ment	3.2.2.c.2	• How do you determine ride quality? • How do you determine that 0.02m is the limit for a 22m span?	MI-63 (A)
Inter-actions	3.2.2.g	The dynamic interactions of vehicle and guideway have not been described in sufficient detail. It will be helpful to understand magneplane if a more detailed description of the guideway/vehicle interaction is given.	LLMJ-13 (A)
Tunnels	3.2.2.k	How are the tunnel diameters determined?	UED-42 (A)
		Has the micro-pressure wave resulting from a high speed vehicle which exits a tunnel been considered?	
Noise	3.2.3.d.3	No estimate of the noise is given.	LLMJ-14 (A)
Screening	5.3.2.2.d.2	The procedures to determine the better designs should be given.	UED-43 (N)
Spans	5.3.2.2.f.1	The design was based on the structural criteria given in 3.2.2.a.2. The dynamic response of the vehicle/guideway interaction has not been adequately investigated.	UED-44 (A)
		ACTION CODES: A – ACCEPTED/CONCUR N – NON-CONCUR W – WITHDRAWN	

MAGLEV

PROJECT Magneplane International

- ☐ Site Development
- ☐ Architectural
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- ☒ Electrical
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NAME: S. S. Chen
ORGANIZATION: ANL
DATE: 5/20/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
Damping	5.3.2.3.b	The ride comfort appears to have not been analyzed. Active magnetic damping may be needed. It appears that much more study on vehicle dynamics should be performed immediately. But it is not included in Work in Progress.	LLMJ-15 (A)
~~Advantages~~	~~5.3.7.1.a~~	~~Magneplane is intended to be connected to shopping malls, industrial and office parks, and residential condominiums. Other means can be used and are expected at lower cost. What are the reasons for such applications?~~	
Economically	5.3.7.1.f	It is not clear why magneplane is better than other maglev systems. More emphasis can be placed on the specific advantages of magneplane.	MI-42 (A)
Magneplane	5.3.7.1.j	"<u>The Germans and Japanese have invested a billion dollars each, but they have not taken advantage of the unique features of maglev. They are no nearer to a practical, affordable system than they where when they started</u>." This appears to be an unbalanced view. ~~Both the Germans and the Japanese appear to have done what they could do under a lot of constraints. Magneplane still has a long way to go. Based on the data available for magneplane at this time, to make such a conclusion appears to be without a solid scientific foundation.~~	MI-43 (N)
~~Magneplane~~	~~5.3.7.1.k~~	~~Japanese EDS is far ahead of magneplane now. Using unproven technology to evaluate proven technology is probably not the best professional approach for our national interest. On the contrary, the best features of German and Japanese systems should be considered for applications to magneplane if possible. This does not mean that magneplane is not as good as Japanese EDS. On the contrary, magneplane might become the best maglev system for US. While the scientific foundation is not yet established, let us look for the truth with an open mind! The goal for our national interest is to develop the best maglev system, which is safe, economical, reliable, and a technological and scientific achievement.~~	

ACTION CODES:
A – ACCEPTED/CONCUR N – NON-CONCUR W – WITHDRAWN

MAGLEV PROJECT: MAGNEPLANE INTERNATIONAL

Howard Coffey
Argonne National Laboratory
22 May 1992

Pg. 56, 3.2.1.a.2.0 No. 3.

The comment is made that the quench of one magnet should not affect other magnets. It would appear that the mutual inductance of the magnets (greater than 10% of the self inductance) would increase the current in the magnet that does not quench, reducing the operational current margin. The unquenched magnet will also be required to carry a greater mechanical load, which it will do by coupling more closely with the guideway image as the vehicle decends slightly. To what extent does this effect reduce the current density margin? How will the suspension height change? MIT-10 (A)

Pg 65, 3.2.1.a.2.3.1

Is there experience with the operation of turboexpanders in significant vibration environments? What are the gyroscopic effects on the turbines? Can the expanders be isolated mechanically? If these cannot be used, what are the backup options and how seriously do they affect the baseline design? MI-64 (A)

Pg. 74: 3.2.1.a.3 pg 74

The statement is made that superconducting magnets operate in the constant flux mode and resistive losses are very small. This does not address the question of ac currents and fields experienced by the magnets as a result of changes in the levitation height. These time varying currents will generate ac eddy current losses in the copper conductor surrounding the superconductor. Since the copper is required for stability, decreasing the filament size of the superconductor will not remove this problem. Has this been calculated for the baseline design? Can some estimates be made? The absence of eddy current shielding causes this problem to be of some concern. MIT-11 (A)

Pg 152: 3.2.1.k.5

How will the infrared detectors be affected by ice or snow on the guideway? RMB-21 (A)

Fig 95: 3.2.1.m.1.1

The drag force is calculated at 110 m/s for comparison of single vs multiple vehicles. Since the relative power requirements to overcome aerodynamics tend to favor multiple vehicles at higher speeds, have calculations been made at other speeds? The assumption that the power capacity for a two vehicle consist is double that of a single vehicle is true on hills or during acceleration, but would not appear to be valid in level flight. Can this assumption be justified? MI-44 (N)

A - Accepted/Concur N- Non-Concur W - Withdrawn

MAGLEV PROJECT: MAGNEPLANE INTERNATIONAL

Howard Coffey
Argonne National Laboratory
22 May 1992

Fig. 3, pg 14. and pg 111

With decelerations of .65 gs during an emergency, will passengers be given notice before applying the brakes so they can brace themselves? Will they need to be belted? This alert time does not appear to have been included in the braking time and distance. Setting the braking time to equal twice the headway time was not discussed and seems somewhat arbitrary. With a suitable time, perhaps 1s if passengers are belted, for reaction of the system controls to respond, the braking time can be reduced to the headway spacing time plus this reaction time, thereby reducing the deceleration to about 0.3 gs. Has this been considered, or is the 0.65 g deceleration inherent in the use of the emergency skids? MI-45 (A)

~~3.1.1.k pg 16.~~

~~The vehicle is not aesthetically pleasing (beauty is in the mind of the beholder).~~

Fig. 11, pg 30.

Have the yaw forces associated with the displacement of the propulsion coils been calculated, and if so what are the effects on the dynamic motion of the vehicle? LLMJ-16 (A)

Fig 16, pg 36.

Have the effects of lift and drag forces on the folded support columns been calculated? Note is made to the 1st and 2nd paragraphs of 2.3.1.a.1.4, pg 40. The vectors depicted in Fig. 23 pg 44 are not explained. MIT-14 (A)

pg. 46

Have stress induced changes in jc of the Nb_3Sn conductor been considered, and if so are what changes are expected? What constraints are imposed by the radius of curvature of the windings of CCIC conductors? Can frictional motion of the conductor occur inside the conduit, and if so, can the temperature rise sufficiently to exceed the margin. MIT-12 (A)

~~Fig. 12, pg 31, and last sentence of 3.2.1.a.1.6.1, pg 54.~~

~~The inductance of the suspension coil is given as 3.1E(-6) and the joint resistance is given as 1E(-9), leading to a time constant of only 50 minutes. This is clearly insufficient for operational purposes if correct. Can this be improved, and by what means? If improvements are not possible, the baseline magnet operating mode might have to be changed to include current leads, with a concomitant increase in refrigeration requirements.~~

A - Accepted/Concur N- Non-Concur W - Withdrawn

MAGLEV

PROJECT Contract # DTFR53-92-C-00006

- [ ] Site Development
- [ ] Architectural
- [x] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other

NAME: S.C. Woodson
ORGANIZATION: CEWES
DATE: 5/22/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	Draft Report of 1 May 92	Rationale for the load factor combinations should be given for evaluation.	UED-45 (A)
2.	"	Connection details of the components of the guideway, particularly that of the truss/girder system to the pier are not provided for evaluation. Some connection details were provided concerning the Aluminum Box beams and the switching mechanism.	UED-46 (A/N)
3.	"	The concrete beam concept is currently being optimized. Reinforcing details should be included in the following report versions.	UED-47 (A/N)
4.	UE&C Supporting Documentation	Node spacing in beam element models appear to be large. Has a sensitivity study (for node spacing) been conducted to verify accuracy of the model? Additionally, it is not clear as to how the loads are distributed to the nodes.	UED-48 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

002 05/22/92 16:09

MAGLEV

PROJECT MAGNAPLANE

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other

NAME: RON MAURI
ORGANIZATION: VNTSC DTS-401
DATE: 5/26/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
	p. 389	ONE STOP AND TWO STOP SERVICE TO 18, 36, AND 72 STATIONS (WITH 20 SECOND HEADWAY) IS ASSOCIATED WITH AT MOST 24 MINUTE SERVICE. THE NUMBER OF 2 STATION COMBINATIONS AND A CRUDE ESTIMATE OF SERVICE FREQUENCY IS:	MI-46 (N)

STATIONS	COMBINATIONS	1-STOP	2-STOP
18	153	17 MINUTES	8 ½ MIN
36	630	70 "	33 "
72	2556	284 "	142 "

ASSUMPTIONS: ① FOR 1-STOP, EACH TRAIN SERVES THREE 2 STATION COMBOS; ② FOR 2-STOP, EACH TRAIN SERVES 6 2 STATION COMBOS.

IT SEEMS THAT THERE IS AN INCONSISTENCY: YOU CAN'T HAVE MANY STATIONS AND FREQUENT SERVICE AND ONLY 1 OR 2 STOPS.

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAY.08 '92 17:29 US ARMY ENGY DIV, HUNTSVILLE P.07

MAGLEV

PROJECT MAGNAPLANE

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [ ] Advance Tech.
- [x] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ______

NAME: RON MAURI
ORGANIZATION: VNTSC DTS-401
DATE: 5/26/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
	PP 357 + 359	(1) HOW WERE FABRICATE/ERECT COSTS FOR CONCRETE BEAMS ESTIMATED?	UED-49 (A)
		(2) HOW WERE ALUMINUM BOX COSTS FOR GUIDEWAY TROUGH ESTIMATED?	UED-50 (A)
		(3) PLEASE PROVIDE LSM WINDING MATERIALS AND ERECTION/INSTALLATION COSTS ALONG WITH SOME DESCRIPTION OF PROCESSES AND ASSUMPTIONS.	FAA-20 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE

PAGE 1

☐ Site Development ☒ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☒ Instr. & Controls ☒ Advance Tech. ☐ Aerodynamics
☐ Structural ☒ Magnetics ☐ Estimating ☐ Other ______

NAME: F. RAPOSA
ORGANIZATION: VNTSC
DATE: 5/22/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	P21	100 MW feeds 4 2km blocks or 25MW/km block. why so large?	FAA-21 (A)
2	P26	252 kA or 252 kAT Which is it?	FAA-22 (A)
3.	P48	Fig 27 is upside down	MI-47 (A)
4	P81	50,000 N is this maximum capability of the LSM?	FAA-23 (A)
5	P81	Figure 50 What are the corresponding stator currents for the data given in the Figure?	FAA-24 (A)
6	P88	Figure 56 shows the acceleration capability exceeding the thrust capability below 20 m/s. Where does this excess thrust come from?	FAA-25 (A)
7.	P88	Figure 56. Shouldn't TOTAL DRAG + ACCELERATION CAPABILITY = THRUST CAPABILITY? IT DOES NOT WHY?	FAA-26 (A)
8	P89	What is meant by "stable speed margin"?	FAA-27 (A)
9.	P97-	The FAA regulations identified - What do these mean in the context of FRA regulations?	BAC-17 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAY.08 '92 17:03 US ARMY ENGY DIV. HUNTSVILLE P.07

MAGLEV

PROJECT MAGNEPLANE

PAGE 2

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [x] Electrical
- [x] Instr. & Controls
- [x] Magnetics
- [ ] Safety
- [x] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ________

NAME: E. RAPOSA
ORGANIZATION: VNTSC
DATE: 5/22/92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10	P112	What are the dimensions in Fig 64? How much kWh capacity for the battery weight shown	BAC-18 (N)
11	P133	Battery running time appears to be based on 100% depth of discharge. What would be the expected battery lifetime?	FAA-28 (A)
12	P167	Cost comparison analysis appears to be based on a "Power capacity factor". This looks to be a meaningless term!! Question all assumptions	MI-48 (N)
13	P222	Figure 134 not consistent with Fig 130.	FAA-29 (N)
~~14~~	~~P228~~	~~What assumptions are to be made for the Stone Segment Test?~~	

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE

...ic Development ☐ Electrical ☐ Safety ☐ Mechanical
...rchitectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
...ructural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: KEN MAURI/TODD GREEN
ORGANIZATION: VNTSC DTS-401
DATE: 5/27/91

...M	DRAWING NO. OR REFERENCE	COMMENT	ACTION
		Small Stations, Page 1 o Would the small stations be connected to the "principal corridor" using double guideway, or can single guideway be used for this connection?	MI-49 (A)
		Emergency Braking, Page 5 o Can the percentage of energy recovered through regeneration be quantified in a general way (i.e., 10%) or would the percentage be route specific only?	MI-50 (A)
		Guideway Configuration Requirement, Section 3.1.3.b., Page 18 o What is the recommended spacing for crossovers?	RMB-22 (A)
		Figure 58 (page 92) and Figure 59 (page 93) o Do vehicles have galleys for food preparation? The discussion on page 134 implies there is, but it's not clear in the figures.	BAC-19 (A)
		Vehicle Cost o When will the cost of the 45 and 140 passenger vehicles be available?	UED-51 (A)
		Vehicle Operation o Will vehicles have an on-board operator?	RMB-23 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT MAGNEPLANE

Site Development	☐ Electrical	☐ Safety	☐ Mechanical	NAME: RON MAUKI / TODD GREEN
Architectural	☐ Instr. & Controls	☐ Advance Tech.	☐ Aerodynamics	ORGANIZATION: VNTSC DTS-401
Structural	☐ Magnetics	☐ Estimating	☐ Other ______	DATE: 5/27/91

EM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
		Entry/Exit Method, Section 3.2.2.d, Page 201 o What is the cost of the switches recommended in this section? o The switch recommended in this section is for 100m/s velocity. Is another type of switch envisioned for low speed operations, such as at stations or in storage yards? If yes, what is the cost? o Is it correct that in a crossover there is no additional guideway required between the switch components?	UED-52 (A)
		Figures 204 - 211, Pages 357 - 365 o When will the LSM Winding cost, and Erect and Align cost be available?	UED-53 (A)
		Capital Costs, Section 5.3.11.2, Page 414 o When will the additional information be available (of particular interest is system electrical & communication requirements and costs)?	UED-54 (A)
		Operating & Maintenance Costs, Section 5.3.11.3, Page 414 o When will these costs be available (in particular, the maintenance hours and material costs for guideway structure, system electrical & communications, switches and vehicles)?	UED-55 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

Notes on the draft SCD Report by Magneplane International, Inc.

The draft report is concentrated on levitation, cryogenic, propulsion, and guideway. It is sketchy on energy, environment, and cost aspects. While the items covered (guideway, cryogenic system, levitation system, and propulsion system) will be evaluated by experts in those fields, the report should be termed incomplete until all aspects are covered.

Some specific comments:

1. Power budget for 50KN is estimated as 7.5MW and guideway resistive losses are estimated as 0.7MW on p.84 (Fig. 53) while power capacity of a single vehicle is estimated as 6 MVA on p.168 (Fig. 95). The input power requirements are calculated in the range of 8.2 to 9.1 MW for speeds 100 to 150 mps on p.220 (Fig. 132). While the numbers on p.84 and p.220 match for the maximum speed, those on p.168 appear to exclude energy consumption for grade climbing. FAA-30 (A)

2. Energy cost computations on p.168 are not clear. The basis for comparison is cost per block where the block is a 2 km length of guideway. A better comparison would be cost per vehicle- or seat-km (see the RFP which calls for cost per passenger-km). Also some explanation of the method used is necessary. MI-51 (A)

3. ~~The assumed energy cost of 8.5 cents/kwh is not supported by any current rates. The average U.S. (industry sector) rate is 5.2 cents/kwh (1990$). The Energy Information Administration (EIA) projects industry sector rates to be 5.6 to 5.7 cents/kwh (1990$) in the year 2010. The basis for using such a high rate (similar to the residential sector rate) should be stated.~~

4. The report mentions vehicle "hotel" power requirements and cryogenic refrigeration system power requirements, but does not include them in energy calculations. FAA-31 (A)

5. The selected 10% discount rate and 50 year life cycle appear high. MI-52 (A)

6. Some inconsistencies are observed in Section F. MI-53 (A)

   Under "Energy Efficiency" the proposed system is claimed to be the most energy efficient among all transportation modes, but no comparison is presented. Wayside power demands are claimed to be lower than any other system while the power demand is close to that of TGV (which requires 8.8MW). Also the maglev vehicles weigh nearly 0.4 tons/seat and not 0.3 as stated on p.391. MI-54 $A)

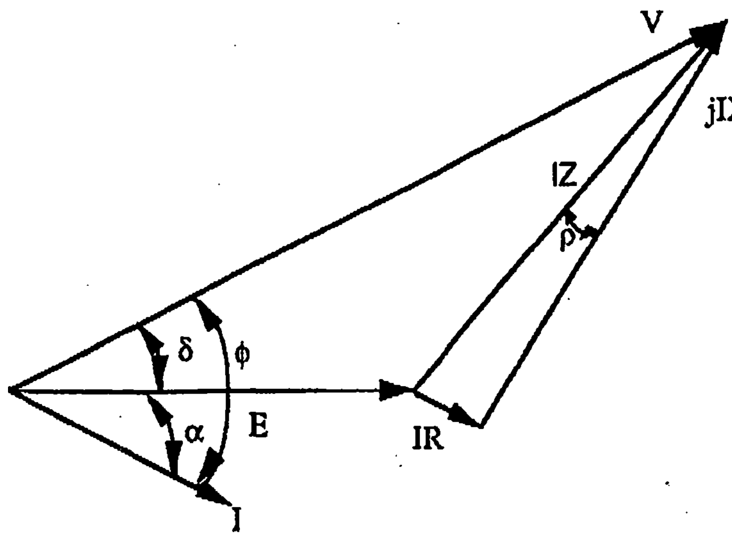
   The claimed guideway cost of $15 million per two-way mile should be checked. It appears low. UED-56 (A)

Comments on Magneplane System

FAA-32 (N)
(3 pages attached)

Z. Wang
5/25/92

The operation point selected for the linear synchronous motor does not seem reasonable because the power factor is too low. On page 217, the author stated that the LSM will produce peak thrust and no levitation force when $\alpha=0$. Indeed, it is true there is no levitation force when $\alpha=0$. However, the peak thrust does not occur at $\alpha=0$. The analysis is as follows:



Phasor diagram

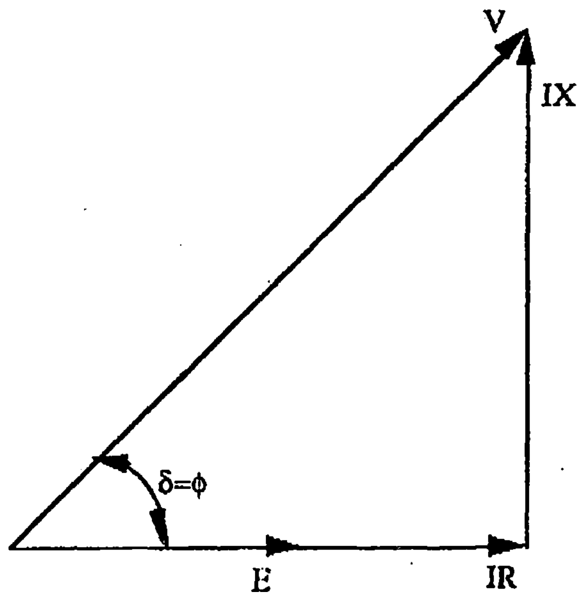
The real power P is equal to

$$P = \frac{EV}{Z}\sin(\delta+\rho) - \frac{E^2}{Z}\sin\rho \qquad (1)$$

Since it is very small compared with inductance, the resistance is ignored. Thus, $\rho=0$, $\sin\rho=0$, and $Z=X$, eq. (1) becomes:

$$P = \frac{EV}{X}\sin\delta \qquad (2)$$

When E and V are kept constant, there is maximum power at $\delta = 90$ degree. Now let's verify that $\alpha=0$ does not correspond with the peak power output.



Phasor diagram when $\alpha=0$

When $\alpha=0$, δ is equal to ϕ and

$$P = VI\cos\phi \qquad (3)$$

or

$$P = \frac{EV}{X}\sin\delta \qquad (4)$$

We know that $\delta = 90$ can result in peak real power. However, from eq. (3), power is zero since $\phi=\delta=90$. These two equations are in contradiction. That means that $\alpha=0$ does not correspond to peak real power and therefore, does not correspond to peak thrust.

Another comment is that choosing $\alpha=0$ as operating point is not good because the power factor is very poor at that point. The contractors considered that at $\alpha=0$, there is no reactive power output so that they thought that the operation point is optimal. For a general rotating motor, it is okay. However for a LSM, the inductance is usually large, especially if a two-km block length is selected. That inductance X will yield lagging reactive power so that the overall power factor is only 0.26. Hence, an operation point with a leading reactive power should be selected to compensate the lagging reactive power (resulting from the long block length) when designing a LSM.

Magneplane International, Inc.
Jet Aviation Terminal, Hanscom Field West
Bedford, Massachusetts 01730
phone: 617 274 8750; fax: 617 274 8747

Responses to COE comments on the Draft System Concept Definition Report

Organized alphabetically and numerically
Referenced on the Design Review Comments sheets

BAC-1 (A) Reference to Airplanes will be deleted in the final report. Ref. 3.2.1.c, Final Report.

BAC-2 (A) References to Oxygen shall be deleted in the final report. Oxygen supplied for medical purposes, ref. 3.2.1.c, FR.

BAC-3 (A) Reference to fuel system was included when it was felt that APU on board power was required. All reference to fuel system shall be deleted in the final report.

BAC-4 (A) Most emergencies shall be handled by the central control station, ref. 5.3.10 and 3.2.3.i, FR.

BAC-5 (A) Figure 63, Freighter version, shall be added in the final report.

BAC-6 (A) The air feed tube shall be correctly located in the final report.

BAC-7 (A) Weight units and a total weight column shall be added in the final report.

BAC-8 (A) SI weight measurement units shall be used in the final report. Metric conversions provided in Final Report.

BAC-9 (A) Same as BAC-3. Reference to fuel tanks shall be deleted in the final report.

BAC-10 (A) Seat dimensions/Sizing shall be added to drawings in the final report. Seat size - standard coach class, ref. 3.2.1.c, FR.

BAC-11 (N) Do not understand the question dealing with conditions on page 90. Ref. 3.2.1.b.7, FR.

BAC-12 (A) FAR's may be too restrictive but the government has not provided any certification criteria to use. We anticipate the real requirement to be somewhere between the FAR's and the FRA's. This will be better addressed in the final report. Ref. 3.2.1.c, FR.

BAC-13 (A) Weight and balance shall be addressed in the final report. Ref. Supplement D, Section F, FR.

BAC-14 (A) A final landing gear extension system shall be addressed in the final report. Ref. 3.2.1.c.3.12, FR.

BAC-15 (A) Baggage shall be addressed in the final report. Ref. 3.2.1.c.3.3, FR.

BAC-16 (A) An initial look at the Americans With Disabilities Act, has not raised any issues that appear to be a problem area. A more detailed review and problem areas shall be addressed in the final report. Ref. 3.2.1.c.8, FR.

BAC-17 (A) FAA regulations addressed in BAC-12.

BAC-18 (N) Dimensions for all equipment in figure 64 are not part of this chart. Kwh capacity for the battery weight shall be added in the final report but, will probably be added in the text in section 3.2.1.g. Electrical.

BAC-19 (A) At the current time there are no plans to provide a galley due to space constraints. On-board electrical power is sufficient to support a galley in the future which is what page 134 indicates.

BCI-1 (N) We believe that the soild criteria established in the SOW were minimal and that additional assumptions were required to complete a "first cut" foundation. However per your request, we will reduce the allowable soil bearing pressure in accordance with the Severe Segment Test parameters and will revise the foundation design accordingly. This will provide consistency between the teams.

BCI-2 (A) See BCI-1

BCI-3 (A) Inclined (batter) piles would help to resist lateral loadings from the magway. They have not yet been analyzed, but may be included in the Hypothetical Route Report, if cost effective.

FAA-1 (A) The battery charging load will be added to the table in the final report. Ref. 3.2.1.g, FR.

FAA-2 (A) Not sure what this comment refers to because there is no page number, but there will be more material on power in the final report. Ref. 3.2.3.g, FR.

FAA-3 (A) Foreign object detection is presently under consideration and will be discussed in the final report. Ref. 3.2.2.i, FR.

FAA-4 (A) These fields will be much smaller than the propulsion field. Further consideration will be discussed in the final report. Ref. 5.3.6, FR.

FAA-5 (A) 6 MVA is for the small (45-passenger) vehicle. Figure 53 refers to the large (140-passenger) vehicle. 12 MVA was selected to allow for additional losses, power factor above 8.2 MW.

FAA-6 (A) 13 MVA is in error. Should be 12 MVA to be consistent with other discussions for 140-passenger vehicles.

FAA-7 (A) Phases and Segmentation.

Phases - The use of polyphase power with more than three phases was considered during the design of the Magneplane system. Higher phase number systems are generally used when three-phase power is incapable of supplying the necessary current. For any given line-to-neutral voltage, the phase current decreases in proportion to the number of phases. Six-phase power has half as much phase current as three-phase power for the same power and line voltage. Present (1992) technology for large inverters allows them to supply power in the range of 5 - 10 MW using only three phases. More power can be provided using multiple output inverter stages coupled together through an output transformer which ultimately supplies three-phase power.

There are significant economic disadvantages in using higher phase power levels. For the Magneplane system, the most significant of these would be the complexity of a higher phase LSM winding. The advantage of three-phase power is that circuit breakers, protective relaying, and other apparatus are available and economical for three-phase equipment only. In addition, there is no significant decrease in conductor materials if the voltage and power are constant. For distribution cables or the LSM winding, the total cross-sectional area of conductors remains the same, independent of the number of phases. Magneplane has chosen to use conventional three-phase power apparatus for its system after considering the factors discussed above.

Segmentation - LSM winding segmentation was investigated during the early stages of the project. The motivation at that time was to provide a sinusoidal field in the air gap of the LSM. One of the requirements was to maintain relatively low space harmonics in the field over the whole range of vehicle height. At that time, the landing gear concept had not been fully developed and the minimum height separation between the vehicle magnets and the LSM winding was considered to be 0.1 m. In addition, the pole pitch at that time was 1.0 m. Using these parameters, very significant distortion would have occurred in the magnetic field if only one or two conductors per phase were used in the LSM winding. Multiple slot, multiple layer configurations for the LSM winding were considered at that time to improve the waveshape of the magnetic field.

Design development work during the project altered the pole pitch of the LSM to 0.75 m and increased the minimum vehicle height to 0.2 m. With these parameters, one or two conductors per phase would provide a sinusoidal field with less than 5% distortion. Segmentation is not necessary.

FAA-8 (A) This will be discussed in the final report. Ref. 3.2.2.f.3 and 5.3.2.16, FR.

FAA-9 (A) Active magnetic damping is not required in the present design and we do not plan to address its feasibility.

FAA-10 (A) Loss of levitation will be discussed in the final report. Ref. 5.3.10.2.2.4, FR.

FAA-11 (A) Fire will be discussed in the final report. Ref. 5.3.10.2.4, FR.

FAA-12 (A) Evacuation will be discussed in the final report. Ref. 5.3.10.2.3, FR.

FAA-13 (A) Levitation/guidance magnet failure will be discussed in the final report. Ref. 5.3.10.2.2.4, FR.

FAA-14 (A) Derivation of this result will be discussed in the final report. Ref. 5.3.2.18, FR.

FAA-15 (A) Inductive pick-up analysis has been completed. Have changed to inductive pick-up on baseline.

FAA-16 (N) Figure 132 shows 9.9 kV phase voltage, which is 17 kV line-line and is consistent with the discussion on page 222.

FAA-17 (A) Yes. See discussion FAA-36.

FAA-18 (N) Wayside power outages will affect the system, and are safety related.

FAA-19 (A) Discussion of levitation modes is being rewritten. The drag components are based on complex analysis. The results will be in the final report. The expressions in Figure 55 are approximations.

FAA-20 (A) Some cost information was presented at the second IPR. A discussion of technical details will be discussed in the final report Ref. Supplement B, FR.

FAA-21 (A) This section will be rewritten and is incorrect in its present form. See block diagrams after page 310 of revised report (per IPR2). Ref. 3.2.3.j, FR.

FAA-22 (A) The correct notation is kAT.

FAA-23 (A) No. See Section 3.2.1.b.6.2 Propulsion Capability, and the thrust-speed curve of Figure 56.

FAA-24 (A) The currents are given in Figure 138 for the same thrust-speed curve.

FAA-25 (A) Thrust capability and acceleration are expressed in different units, and are represented on the graph in Figure 56 on different, independent axes. The locations of the different curves on the graph are not relevant.

FAA-26 (A) See response FAA-25.

FAA-27 (A) A stable speed margin is a range above and below the nominal speed for which the vehicle can successfully execute the turn.

FAA-28 (A) Battery life will be designed to be at least five years. It will depend on number and depth of discharges.

FAA-29 (N) Figure 134 shows how series capacitor compensation may be used to improve power factor. See report discussion.

FAA-30 (A) Figure 95 compares single-vehicle and multiple-vehicle consists at nominal operating conditions on level magway.

FAA-31 (A) The on-board cryogenic system is included in the vehicle hotel power budget. It is not clear which energy calculations the comment refers to. Ref. #.2.1.g, FR.

FAA-32 (N) The assumptions used by the reviewer do not apply to our analysis. Resolution of the reviewer's contradictory equations and a detailed response to the comments are included in the attached discussion.

LLMJ-1 (N) The aerodynamic assessments completed are adequate for the system concept definition stage and are based on proven methods and available data. A detailed aerodynamic design requires a completed vehicle design, computational fluid dynamic calculations and component wind tunnel tests, which are not required at this stage of the program.

LLMJ-2 (A) The keel effect is being considered further in relation to curve performance.

LLMJ-4 (A) This is part of the on-going 6-DOF simulation of vehicle dynamics.

LLMJ-5 (A) Figure 75 shows the typical steady roll angles and lateral offsets in side-winds and figure 74 the accelerations on entering a gust. Airspeed and ground speed can be measured separately to determine gust speed.

LLMJ-6 (A) Ride quality assessment due to gusts and turbulence is on-going. Ref. Hypothetical Route Report, Section 4, FR.

LLMJ-7 (A) The angular rates are used with the vehicle forward speed to determine the effective local angle-of-attack and hence the aerodynamic damping forces and moments due to angular rates.

LLMJ-8 (A) This table is being extended to show effect of other lateral accelerations and track geometry variations, such as gap between levitation plates. Ref. 3.2.1.1, FR.

LLMJ-9 (A) Assessment of noise abatement is on-going. Ref. 3.2.1.f, FR.

LLMJ-10 (A) Passive aerodynamic damping was estimated and used to determine the suspension damping factors given in Figure 81, p. 138. These factors were deemed unacceptable.

While the dynamic flexibility of the vehicle has not been studied explicitly, we are aware of the potential for interaction between the structural resonance modes of the vehicle and the aerodynamic and linear synchronous motor (LSM) actuators. Our approach has been to specify a maximum actuator bandwidth and a minimum structural resonance of the vehicle with sufficient separation between the two frequencies to ensure no unwanted interaction between them. The structural resonances can then be "notched" out of the actuator response to keep from exciting these modes. A second approach is to use the actuators to actively control the principal bending modes of the vehicle, allowing an increase in the overall system bandwidth and disturbance rejection. The former approach is a more passive (and conventional) method for ensuring no adverse interaction between the actuators and the structural modes of the vehicle, while the latter method requires a more precise and complex model of the structural modes of the vehicle as well as higher bandwidth actuators and greater computational requirements. The advantage of the latter method is the greater frequency and magnitude of disturbances which can be actively rejected.

The 5 Hz natural frequency of the vehicle was chosen to allow aerodynamic actuator bandwidths of above 3 Hz, which we believe will be required to reject most of the disturbances seen by the magneplane. We are investigating increasing the actuator bandwidth to 6 Hz and the structural resonance to 8 Hz to get additional disturbance rejection. This topic is an area of ongoing concern and it is included for further study in the test plan proposal.

The magneplane requires the use of the LSM or the aerodynamic actuators to maintain stability. We believe that the principal mechanism of the unstable modes is the coupling of the pitch/heave motions with the propulsion of the LSM, which can inject energy into the system. Since the LSM only operates in a closed-loop manner, this unstable mode will always by controlled. There is sufficient redundancy that several actuators can fail before the system cannot be stabilized. We have proposed further study of fault tolerance and fault detection methods in the test plan proposal.

The time constant of the unstable modes are extremely long (the shortest one is 40 seconds), allowing them to be easily stabilized by the active control system. This is not unlike many high performance sailplanes which have stable short period pitch modes but unstable long period pitch modes (sometimes referred to as the phugold mode) on the order of tens of seconds. The unstable modes are long and slow and are stabilized by the pilot alone, and can be easily stabilized by an automatic control system. The primary method of studying the stability of the magneplane has been to examine the eigenvalues and eigenvectors of the linearized system. Although this has not yet been explicitly addressed, we expect to include such a section in the final report.

The control law for the magneplane is a full-state feedback state-space controller using the full twelve states of the vehicle (six degrees of freedom plus their time derivatives). We have chosen a state space gain matrix using the linear quadratic regulator (LQR) methodology. We hope to compare the LQR controller with a direct covariance design controller and a robust design controller. All of these design methodologies make an optimal choice of constant gain, full-state feedback matrices based on different mathematical definitions of optimality. They are all designed for simultaneous control of multiple-input, multiple-output (MINO) systems. This is inherently different from a single-input, single-output (SISO) control loop, as in a pitch only control loop, which may use a proportional-integral-derivative (PID) control law with lead-lag compensation. The state-space methods are designed for MIMO systems and the general case where there is coupling between the control axes, whereas the SISO system generally must assume no coupling between the control axes--not a good assumption for the magneplane.

LLMJ-11 (A) The methods for estimating passive aerodynamic damping are typical of those used successfully in aircraft dynamic response calculations.

LLMJ-12 (A) Active damping and guideway interactions are included in the dynamics modelling. Guideway roughness is characterized with a power spectral density. Motion dependent aerodynamic forces are included in the models. The vehicle is inherently stable statically and the keel effect provides good guidance forces and moments. The passive damping is small but positive in most modes. However, a divergent oscillation associated with heave, pitch and speed variations occurs and is controlled actively using the LSM. Study of vehicle dynamics and ride-quality represents a significant on-going effort. Ref. 3.2.1.el, 3.2.2.g and HRR, Section 4, FR.

LLMJ-13 (A) Various aspects of vehicle/guideway interactions are discussed throughout the report but a summary assessment will be included here. Ref. 3.2.2.g, FR.

LLMJ-14 (A) Side-line noise values are given in Figure 225. Additional work on noise impacts is in progress. Ref. 3.2.1.f, FR.

LLMJ-15 (A) Vehicle dynamics is a significant continuing effort. Ref. 3.2.1.l and 3.2.2.g, FR.

LLMJ-16 (A) The propulsion coil/guideway interactions have been assessed and are being used as part of the dynamics simulations.

MI-1 (N) The "operation" of the superconducting magnets is independent of the levitation sheets. Once the magnets are charged, the only additional power required to keep them operating is for the cryogenic system.

MI-2 (A) These figures will be corrected in the final report.

MI-3 (A) The formula is incorrect but demonstrates a basic point. Detail and clarification will be added to the whole section. Ref. 3.2.3.i, FR.

MI-4 (A) SI units will be used in the final report.

MI-5 (A) Figures will be properly oriented in the final report.

MI-6 (A) SI units will be used in the final report.

MI-7 (A) Detail and clarification will be added to the whole section. Ref. 3.2.3.i, FR.

MI-8 (A) The formula is incorrect but demonstrates a basic point. Detail and clarification will be added to the whole section. Ref. 3.2.3.i, FR.

MI-9 (N) Section 3.1 is not part of the executive summary. It is the System Criteria (part of the SOW outline). Perhaps the placement of tabs A and B led to this confusion.

MI-10 (A) Goals 2 and 8 are integral parts of the concept being evaluated, and this concept is the contractor's concept and not the government's concept.

MI-11 (N) The customary notation for the force due to gravity is "mg" where m is the mass of the object and g is the acceleration due to gravity ($g = 9.8\ m/s^2$). In cases where "g" might be confused with the notation for grams, "gee" may be used. Since neither mules nor sled dogs are involved in our maglev concept at this time, it is unlikely that any confusion will result from the use of "gee".

MI-12 (A) (1) Sub-optimal curve performance was under study at the time of the draft report. The final report will demonstrate that a sufficiently wide range of velocities in a curve is possible. (2) Low speeds in curves are only required in emergencies, at which time using a tow vehicle is a reasonable solution to the emergency situation. Ref. 5.3.2.21, FR.

MI-13 (A) Air lubrication per se is not prorietary, but air lubrication in the present context and in this specific embodiment is. According to US patent law, the novel use of a known element is patentable providing it is an improvement over prior art and not obvious to a practitioner of the art.

MI-14 (N) The concept being studied is the contractors and not the government's, and is aimed at future requirements, not past or present requirements. 7 lanes of interstate highway are less than the 42 lanes estimated to be required on I-95 north of Miami by the year 2016, according to official Florida projections. A system that cannot meet requirements in 14 years is not worth defining, much less building.

MI-15 (A) Figure 50 was evidently not referenced in the text. This will be corrected in the final report.

MI-16 (A) Figure [FAA-321-5] is figure 52. This will be corrected in the final report.

MI-17 (A) At 45 degrees of roll, the minimum radius at 134 m/s is 1.8 km. At 35 degrees, it is 2.6 km. At 24 degrees, it is 4.1 km. (Page 327 gives the background for this.) The vehicle can naturally negotiate these curves without issue, but as with any new concepts, it is public acceptance that imposes the real restrictions. As discussed in 3.1.3, and depicted in figure 3, a 25° roll is (nearly) accommodated in the definition of the "BEST" ride quality standard, and hence preferred. If the passengers are seat belted and the route has one tight curve in an otherwise fairly straight section, a 45° roll is possible, permitting a 1.8 km radius curve. The text discussions were based on an earlier version of figure 3, and as with all concepts, there have been changes, resulting in the examples not directly correlating with the other text (ie, assuming a 35° maximum bank angle). This will be corrected. From the aspect of banking capability, curves less than 1.8 km have to be traversed at less than 134m/s, ie at 134 m/s the minimum radius is 1.8 km.

MI-18 (A) This comment is absolutely correct, and the error is the result of a mistake in compiling the (significant) text and figure data from various sources. Figure 69 should be referenced figure 70, and vice versa, in the text and in the order presented. The new figure 70 should be moved to proceed the text and the new figure 69.

MI-19 (N) The table *only* shows that consists of 1-4 vehicles are roughly the same cost, as the costs associated with coupling were only estimated (Magneplane has not designed a multi-vehicle system for comparison.). Even if single vehicles cost $2M more per block over 50 years, the extra cost would be worth the benefits given in figure 96.

MI-20 (A) Figures will be properly placed in the final report.

MI-21 (A) Figures will be properly placed in the final report.

MI-22 (A) Figures will be properly placed in the final report.

MI-23 (A) This work is out of scope of the contract; however, a short response is in order: The marketing implications have analogies to taxis in New York city, versus personal vehicles and the underground train system. Taxis are popular and abundant because of dynamic scheduling. Low demand station pairs should be the result of recognizing the need for the stations at critical areas, and providing special consideration to offer such service. This is consistent with other forms of transport. The smaller (45 passenger) vehicle offers lower operating cost and would obviously be used in such a scenario. The trade offs required in making such service availability decisions are encountered in every public transport facility, and the rules that apply are very similar.

MI-24 (N) Both vehicle sizes can still be used, but the 140-passenger vehicle was selected as the "baseline" size used for costing and the Hypothetical Route Report.

MI-25 (N) Operational capacity is under study. Empty slots will in any case be a small minority of total slots.

MI-26 (A) The braking specification is 4.9 m/s^2. Occurrances of other numbers will be corrected in the final report. Ref. 3.2.3.j, FR.

MI-27 (A) Costs will be given in $/m.

MI-28 (A) Figure MJF 10 is Figure 217. This will be corrected in the final report.

MI-29 (N) Compared to aluminum, iron may require less electrical power, but it requires both coal and taconite, neither of which is widely available. Coking furnace and blast furnace pollution is more difficult and expensive to remedy than pollution from nuclear and fossil-fuel electric powerplants.

Aluminum is therefore ecologically advantageous.

MI-30 (N) Long maglev commutes permit the implementation of "Green Belt Zoning" laws which have been very successful in England and elsewhere in saving and restoring the inner cities.

MI-31 (A) Mobility "in and of itself" does not save cities, but mobility combined with intelligent regional planning does, such as practiced in Scandinavia, for instance.

MI-32 (A) Incomplete coverage will be completed in the final report wherever possible, but no schedule can be given at present, and no detailed design can be performed under a "System Concept Definition Study", even if lack of a final engineering design impacts the cost estimate.

MI-33 (A) System requirements to the contrary notwithstanding, a fuel-fired APU had to be pursued until feasibility of inductive pickup has been established and a trade-off comparison has been made, because on-board APUs are established aircraft technology approved by the FAA. The requirement to use non-existent and potentially impossible technology without back-up is arbitrary and unacceptable. The concept being defined is the contractor's concept, not the government's. Now that feasibility of inductive pickup has been established, fuel will not be used in the final concept.

MI-34 (A) The emergency brake rate is as high as 4.9 m/s^2. The safety report will address double failures and the effects on passengers. On December 16, 1991 a meeting was held at the Volpe Center to established revised ride quality standards. At this meeting it was specified that there is to be no limit on the emergency deceleration rate. This specification supersedes any earlier specification. It should be noted that there is no limit on the emrgency deceleration rate of a bus or any other carrier for that matter, nor any requirement that passengers be notified in advance before the driver makes a panic stop.

MI-35 (A) Emergency braking rate can be accurately controlled by the amount of extension of the brake pads.

MI-36 (N) The clearance between vehicle skin and magway surface is 15 cm. The gap between the levitation magnet coil center and the magway surface is 20 cm. The gap between the propulsion coil center and the propulsion winding center is 25 cm.

MI-37 (A)

(1) The advantages of Magneplane are inherent in the objectives and the design rationale, which is described in considerable detail in the introduction, and in even more detail in the proposal and the "best and final offer" document. US should select the concept which best meets US requirements, providing the concept is shown to be feasible technically and economically. It is believed that concepts which offer nothing more than faster railroads do not meet US requirements.

(2) The ride quality standard chosen depends on the curviness of the route.

(3) Maglev can provide longer-distance trips, but many passengers would still prefer airplanes for very long distances.

(4) Maglev is needed at shopping malls not to go shopping, but because shopping malls are among the most accessible points in suburbs, and because infrastructure (ie. parking space) already exists there.
(5) The dominant economic issue is Magneplane's ability to compete with the automobile, which accounts for 90 percent of most corridor traffic in the US, amd which is responsible for most of the congestion, gridlock, pollution and energy dependence, both in the US and elsewhere.

MI-38 (A) If a vehicle is unable to operate at design speed (presumably because of a subsystems failure) it will be removed from service.

MI-39 (A) Evidence from the Japanese maglev team and experience with aircraft wheels gives a very strong indication that pads are better than wheels. Further research into air-lubricated pads is required.

MI-40 (A) Figure 2 will be clarified in the final report.

MI-41 (A) Nice cost estimates were supplied at the In-progress Review; further work is being done and will be included in the final report to the extent possible. This is not a detailed design study. Ref. Supplement D, Section G, FR.

MI-42 (A) More emphasis will be given in the final report to the advantages of Magneplane. Ref. 5.3.7, FR.

MI-43 (N) Details were provided in the opening presentation at the In-progress Review. The Japanese system is inherently unstable, even after two configuration changes.

MI-44 (N) 110 m/s was chosen because it represents a typical average velocity (refer to the preliminary Hypothetical Route Report for some actual averages). The assumption that two vehicles require twice the power of one less the savings due to reduced aeodynamic drag is true because there is no other advantage to coupling vehicles.

MI-45 (A) Safety and braking and the relationship between braking capability and headway will be discussed in detail in the final report Ref. 3.2.3.i, FR.

MI-46 (N) Clearly the three objectives of many magports and frequent service and few stops are objectives which work against one another. However, it is possible to find a compromise that has *enough* magports, frequent *enough* service, and few *enough* stops to be an attractive alternative to the automobile. A discussion and example will be included in the Advantages section of the final report, but a formal demonstration would require computer modelling which is outside the scope of this contract. Ref. 5.3.2.4, FR.

MI-47 (A) Figures will be properly oriented in the final report.

MI-48 (N) The term "Power capacity factor" assumes that drag is proportional to the number of vehicles and power is proportional to drag, clearly valid assumptions.

MI-49 (A) Way off-line magports can be connected to the principal corridor via single bidirectional magways.

MI-50 (A) The percentage of energy recovered in braking is almost zero on long straight routes, but the theoretical limit is about 44% for 0.4g. The first half of the severe segment test recovers about 35%.

MI-51 (A) The analysis will be clarified in the final report. Ref. 5.3.11, FR.

MI-52 (A) The cost estimate is being re-evaluated in cooperation with the COE cost group to ensure uniformity among concepts. Analysis was performed using the guidelines established and verified by the COTR.

MI-53 (A) Inconsistencies in the supplementary reports will be corrected in the final report.

MI-54 (A) "Energy Efficiency" and "Power Demand" are not identical concepts. Power demand is the maximum wayside power which must be available in a given block to meet worst-case requirements in that particular block. This does not necessarily mean that all of the available power will be used all the time. TGV has very low accelerlation capability and certainly cannot stop every 15 miles. With a single locomotive, TGV would take 42 km to reach 300 mph. Magneplane would take about 2.2 km. Thus TGV will use all available power most of the time, while Magenplane will not. The exact energy efficiency will be calculated by our computer model for specific cases. Magneplane is likely to be more energy efficient than any railroad concept because it doesn't accelerate 800 to 1,000 passengers at every magport, most of whom did not want to stop at that magport.

MI-55 (N) The case of total simultaneous triple failure of (1) magway power (2) emergency brake deployment and (3) magnet quenching would be the worst case as the comment stated. The topic of double and triple failures will be covered in the reliability plan and in the safety plan. Safe headway is calculated on the assumption that one of the reduntant mechanisms for stopping works, just as safe headway is calculated for all other forms of transportation.

MI-56 (A) The cost sensitivity analysis will be included in the final report. Ref. 3.2.3.f, FR.

MI-57 (A) The camera surveilance system will be costed as a separate item. Whether it is used or not, and in what locations, is subject to further study and depends on requirements to be determined outside the scope of this contract.

MI-58 (A) This statement was accidentally included, having originated in an earlier magway design. In fact the trough is closed in the center with provision for drainage. In any case, noise will be addressed as the comment recommended. Ref. 3.2.1.f, FR.

MI-59 (A) The LSM windings are encased in a solid material, which is designed to withstand the forces associated with landing gear, emergency braking, and repair vehicle wheels. Emergency braking in a horizontal curve would cause contact between the brake pads and the center of the magway trough where the windings are located. The coefficient of friction under various conditions between the brake pads and both aluminum and the winding-encasing material will be tested during the pad development stage, but not during this contract.

MI-60 (A) The magway was always shaped like a trough; there has been no change. The methods of ensuring clear magway will be discussed in the final report. Ref. 3.2.2.i, FR.

MI-61 (A) The reliability plan was not included in the draft report because it wasn't done. It will appear in the final report. Ref. 3.2.3.h, FR.

MI-62 (A) The units will be included in the final report.

MI-63 (A) Ride quality is determined in the ways described in the vehicle dynamics section (3.2.1.el) and the Hypothetical Route Report. The ride quality standards chosen by the government are reprinted in 3.1.1. The deflection tolerance chosen is the basis for the active damping system design, which in turn ensures adequate ride quality. The projected capability of the active damping system is the basis for the deflection tolerance given.

MI-64 (A) Adequate discussion will appear in the final report. Ref. 5.3.2.37, FR.

MI-65 (A) The confidence level of adopting air-bearings in high. Development work will be required. The alternative (the wheel) is an inadequate technology for this application.

MIT-1 (A) Work is in progress and will be included in the final report. Ref. 5.3.6, FR.

MIT-2 (A) Work is in progress and will be included in the final report. Ref. 5.3.2.21, FR.

MIT-3 (A) Work is in progress and will be included in the final report. Ref. 5.3.6, FR.

MIT-4 (A) Work is in progress and will be included in the final report. Ref. 5.3.6, FR.

MIT-5 (A) Yes; Work is in progress and will be included in the final report. Ref. 5.3.6, FR.

MIT-6 (A) Agree with comment; No action required.

MIT-7 (A) MIT/PFC has used both commercially available and internally developed computer codes to carry out the various magnetic field analyses required during this program. They include the following:

Commercially Available:
- ANYSIS (Swanson Associates)
- ELECTRA (Vector Fields)
- ECTAS (Hitachi)
- EDDYCUFF (Mitsubishi)

Codes Developed by MIT/PFC
- MITMAP (Licensable)
- SOLDESIGN (Licensable)
- Several Other Shorter Codes

Restoring forces have been computed and will be included in the final report. Ref. 5.3.2.1, FR.

MIT-8 (N) Lift module overall geometry is presently envisioned as being the same for both vehicles. This allows for common tools for installation and maintenance, as well as a common "turn-key" coil charging system. An option still exists to reduce the number of turns in the coils for the small vehicle to provide the same design margin for the reduced lift requirement; alternatively, the same modules could be used to allow for complete interchangeability between large and small vehicles, but the small vehicle coils would be charged to a lower current level. A choice of this type has essentially no impact on conceptual design, and a small impact on cost. It is believed to be a higher order design decision that should be considered at a later stage of more detailed cost projection.

MIT-9 (A) The finite element code used for the referenced figures was ANSYS. A note will be added to the final report.

MIT-10 (A) The current in a non-quenching lift coil due to the quenching of a lift coil in the same lift module would lead to a current increase that is bracketed by the range 10-50 %. The usual operating point for this conceptual design is at less than 40% of critical current, hence the quench of a single coil would raise the fraction of critical current in the adjacent coil to the range of 44-60%. This is believed to be adequate margin for the conceptual design. During a later phase of design it will require consideration in more detail, in view of the overall system response. It may, for example, be advisable to activate a quench in the corresponding coil on the opposite side of the vehicle using heaters near the windings and, simultaneously begin a controlled vehicle speed reduction.

MIT-11 (A) AC losses in CICC type conductors can be controlled by adjusting filament size of the superconductor in a strand and/or by adjusting the strand size of the composite conductors forming the cable used in the conduit.

We have allowed for a heat loss of 1 W per coil as a budgetary target for conceptual design purposes and plan to alter the conductor geometry in a future design iteration to meet the target if necessary. Estimates can be made of the AC losses, but calculations are intricate and measurements are essential. They should clearly be pursued as a follow on activity to the SCD studies.

Eddy current shielding is not totally absent in our design in that the present external dewar walls are fabricated from 10 mm thick aluminum and effectively shield AC field components (eg-from LSM harmonics). A discussion will be added to the final report to cover these items which are not believed to have a significant impact on the conceptual design.

We have not computed eddy current losses in the conductor for changes in vehicle height. We expect a detailed analysis of eddy currents to be undertaken as a task in the next phase of the MAGLEV program. Preliminarily, however, recent parametric studies at the MIT Plasma Fusion Center indicate that eddy current losses are small in superconductors operating under similar conditions to those anticipated for MAGLEV.

There are a number of design options available to us for reducing ac losses that we can consider in the next phase of the program, if necessary. Options include changing the conductor configuration (e.g. from 54 strands to 108 strands) to reduce the characteristic dimensions of both the individual strands and the conductor cable, thereby reducing eddy currents in the overall conductor. Another option is to shield the conductor to reduce eddy currents. Also, depending on the frequency of the change in levitation height, we expect to get a shielding effect from the 3/8" thick (10mm) wall of the aluminum cryostat.

MIT-12 (A) Stress induced changes have been considered as well as radii of curvature. The fusion program has demonstrated that stress induced changes can be controlled by the selection of a low coefficient of expansion conduit material in this type of conductor (eg- Incolloy 908) coupled with a displacement controlled coil structural design. We also plan to use the "wind and react" technique proven on fusion coils for forming the Nb_3Sn after the coil is made thus alleviating any problems associated with radii of curvature during fabrication.

The cable is not free to move within the conduit and local relative motion and possible frictional effects are constrained. The cable is made up of several subcables that are twisted and placed in a round conduit which is then formed into a square. During the latter process it is also drawn and compacted, thus holding the cable tightly at all the crossing "high points" of the cable wires. The operational stability of this type of conductor has been demonstrated in the fusion program with much larger cables under much higher fields and loads than are anticipated in maglev.

MIT-13 (A) The length of the switch required is under study, but the example demonstrates that substantial lateral forces to turn the vehicle can be developed with small centerline offsets. The CDR indicated that a lateral force equivalent to 1-1.5% of the lift could be generated with a small offset of 15 mm. The lateral force is roughtly proportional to offset and could therefore be substantially larger if required. The actual offsets will require the dynamic analyses of the vehicle as it traverses the switch, howver, this example shows that the necessary lateral force is possible with this concept.

MIT-14 (A) Lift and drag effects on the folded support columns were estimated and are shown in the stress and displacement contours for the FEA model in figure 26, page 47. The displacement figure is drawn with displacements exaggerated in scale and allows the lateral deflection of the nested cylinders to be seen clearly

Figure 23 will be explained further in the final report. The vectors are the local loads of electromagnetic origin on the winding and include lift and drag, which are small parts of the forces shown. Ref. 3.2.1.a.1.4, FR.

RMB-1 (A) The referenced paragraph 3.2.1.d.1 discusses braking philosophy, and not specifically headway considerations as identified in the COE comment. Discussions on headway are elsewhere in the document (ie 3.2.3.g.2 Switch Control and 3.3.3.j Maximum System Capacity). These discussions will be enhanced and cross-referenced in this section, but not re-iterated. Inconsistencies on braking forces will be corrected in the final report.

RMB-4 (A) The sentence is rewritten as follows: " The system features a computer architecture which provides fault-tolerant operation through hardware and software failures. The hardware topology insures that any critical operations can be sustained during two failures without impacting safety and performance. ~~A third failure will not impact functionality and allow no further degradation of safety (fail-safe).~~ **A third failure excludes no-fault verification, which can result in reduced performance, and will induce corrective action (stoppage), but no loss of functionality or degradation of safety (fail-safe) occurs.** For activities related to mission completion, redundancy is implemented to allow fail-safe electrical operation."

Explanation: Critical items are quadruplexed (have four controllers). If two fail, the voting mechanism insures the two working controllers dominate. If three controllers fail, dependance is placed on the software (history, extrapolation, prediction) for the fourth controller to proceed, resulting in reduced performance, but no loss of functionality. This degree of failure should induce whatever action is required to remove dependance on the critical item being controlled. This typically results in a coordinated abort of the mission, with no degradation of passenger safety, as control is maintained until the abort is complete. If the fourth fails, the controlled critical item should default to it's safest (benign) operating point, permitting external corrective action to incur minimum damage as it proceeds.

RMB-5 (A) The purpose of the position markers is to keep track of when to anticipate curves or other required maneuvers, and to verify to the global controller the vehicle location. The vehicle is propelled by a magnetic wave front generated in the magway, hence the wayside unit automatically has knowledge of the vehicles position to within one meter. When the vehicle exits a magport (station), its position is known and the velocity is low (reducing spatial offset errors). As the vehicle gains velocity, it also acquires considerable position and rate data (by integration and from the accelerometer packs), insuring the initial accuracy is maintained. With the knowledge that the vehicle cannot take a quantum step, in position or velocity, the proposed RF concept appears to be adequate and robust (compared with alternates). It is agreed that analysis of the concept performance is required, and preliminary evidence will be generated for inclusion in the next published version of the document. Position data to 10 meters does not represent a mission critical parameter.

RMB-6 (A) Correct. Details of how cross-wind perturbations will be accommodated will be in the final report. The height sensors and inertial instruments will detect cross wind perturbations, and permit aerodynamic compensation. It has to be determined if this compensation is desirable. Ref. 3.2.1.k, FR.

RMB-7 (A) Yaw transducers permit sensing relative wind direction, which is useful data in compensating for cross-wind perturbations. As defined in the previous response (RMB-6), it has to be determined if compensation for these perturbations are desirable. If it is determined that compensation is unnecessary then these sensors will not be required. This will be reflected in the final report. Ref. 3.2.1.k, FR.

RMB-8 (A) Although not demonstrated definitievly, the aerodynamic control surfaces have been sized to provide adequate control authority as indicated in figures 93A and 217. Also note that the vehicle is levitated, and not relying on relative air pressures to generate lift and maneuvering forces. The magway confines the flight of the vehicle, providing the lift and deviation forces to prevent it from making contact. This is a single direction force that cannot (unless substantially increased) cause the vehicle to leave the magway. There are issues that require addressing on the control authority, they are significantly less rigorous than other maglev concepts, and they will not be fully understood until many hours have been logged on a prototype system. It is intended that this topic is given more attention for the next iteration of the report. It is not anticipated that all the issues can be finalized in the concept definition phase.

RMB-9 (A) The state-of-the-art deicing equipment referred to is currently used on the Beech Starship. It consists of ultrasonic sensors whose resonance changes as ice forms on the exposed probes, permitting automatic detection and cyclic switching of heater elements in the leading edges of the control surfaces. This automatic control of the heaters achieves optimal power performance. The absolute amount of power required for de-icing is determined by the total area required on the control surfaces, and anticipated environments that the system must operate through. As both of these issues are the subject of continued analysis, it is not currently possible to derive a meaningful estimate of the average power burden on the vehicle. It is not however, anticipated that the burden will exceed more than 1% of the total power required by a vehicle in normal operation.

RMB-10 (N) The 200Hz requirement is consistent with the Global Data Rate. It also permits the concept of generating the propulsion wave-form directly from the vehicle (89Hz at 134m/s), which has potential of a simpler and more effective drive control system. Position data is not the only information passed by the vehicle. The most significant data element is the propulsion requirement, which does benefit from the 200Hz rate. The accelerometer bank and integration of history permits the vehicle to interpolate intermediate velocities, hence position, more accurately than the 11 meters of the fixed magway transmitters. As the vehicle is travelling on a magnetic wave front (of 1.6 meter length), the wayside unit is also cognizant of the vehicles position, and can further augment the position data determined from the markers. It was not intended that the concept for communication centered solely about the data rates required for position information.

RMB-11 (A) Yes, when appropriate. This is part of detailed design, and consistent with good design practices.

RMB-12 (A) External (RF) communication failure will result in the vehicle not providing responses to the wayside commands. After a number of successive wayside commands have been ignored by the vehicle (10 attempts, 50mSec), it will be apparent that there is an impending situation. The wayside unit has knowledge (and control) of the vehicle velocity and position, hence it is able to take corrective action. As the system is configured such that the vehicle autonomously induces a braking maneuver if communication is lost, it is reasonable that the wayside, and Global control can accommodate and assist in this maneuver.

RMB-13 (A) The wayside power system forms part of the vehicle control, and as such adopts a similar fault tolerant, redundant philosophy. A trade will be performed on the reliability aspects of increasing fault tolerance and reducing redundancy. To produce the system reliability estimates requires some detailing of the power converter, and the philosophy of redundancy for the power electronics / switching hardware. This work is ongoing and has to be completed before meaningful reliability predictions can be offered.

RMB-14 (A) It has been established that humans will not be "in the loop". Human entry will occur, in order to deal with dynamic resource allocation and situations that arise. The result of their input will be streamed "into the loop" in a coordinated manner by the automatic control system. The automatic control system can and will make decisions on traffic flow, headway, and situations, autonomously, faster, and more consistently (reliably) than achieved with human intervention. The control system itself is operating at a 200Hz communication rate to each wayside controller. The confined routes taken by vehicles permits all the rules checking required by the controller, to prevent situations arising from human entry/commands. This is no different from relying on the traffic flow scheme in central New York city, where the lights are coordinated by computers. The concept for Magneplane is obviously enhanced beyond traffic light control, in consequence of the newer technology being proposed.

RMB-15 (A) It is recognized that the mechanical switch imposes a burden on the through traffic by requiring a time slot to traverse. This is being aggressively addressed by developing a magnetic switch concept. A mechanical switch requires **one** vacant time slot to accommodate the 12 second cycle time. In practice, a real (reasonably complex) system will utilize the bunching scheme described, as well as grouping of vehicles bound for one destination. When a singular vehicle is exiting it does require a 40 second headway for that maneuver, where as with **all** vehicles on line traversing from one source to one destination, only a 20 second headway is required. In practice the **average** headway will be less than 40 seconds, and if the system is designed correctly, closer to 20 seconds.

RMB-16 (A) The control structure is distributed in a hierarchical manner. The vehicle has to respond and control its local environment, which is within the bounds of the vehicle length. The wayside units must control the vehicle in a block. The global centers control multiple vehicles in an area. Each control function performs some actions autonomously (which requires intelligence), and the functions are fully integrated so that the next higher level of control can predict the response of the lower element if communication fails or an abnormal situation occurs.

RMB-17 (A) In an emergency, the prime consideration is safety of the passengers. When circumstances permit, the number of vehicles in a block will be no more than one. A stationary vehicle in a block will be restarted in a similar manner to that instigated at a magport. In some circumstances it may be necessary to have more than one vehicle in a block. It has not yet been established, if, when more than one vehicle is stationary in a block, there is adequate power available to 'creep' the vehicles until the front one transitions to the next block. Vehicle creeping can be performed with the LSM for a number of vehicles simultaneously. Communication for each vehicle to the wayside unit is achieved with the packet switching technique described, hence there is no communication conflict. A slowly moving magnetic wave front can be used to creep multiple vehicles in one block. Towing vehicles are also being considered and maybe used if required. The advantage of bunching during emergency braking is that vehicles further back from the incident can brake less aggressively and reduce the risk of injuring standing passengers.

RMB-19 (A) Reliability analysis of the vehicle (and system) design is an ongoing task. The results of a preliminary analysis will be included in the final version of the concept definition report. Ref. 3.2.3.h, FR.

RMB-20 (A) Although passively stable in most modes, there is an unstable oscillatory mode involving the coupling between speed variation and heave/pitch motions, as discussed in LLMJ-10.

RMB-21 (A) The infrared triangulation detector scheme is favorable for height sensing because of the relative insensitivity to external environmental changes. Multiple sensors will be used to determine vehicle height at a number of locations along both sides of the vehicle length. Ice build up on the magway will cause diffraction errors, possibly ghosting that will degrade the accuracy of a single sensor. Correlation of multiple sensors avoids misinterpretation of erroneous measurements. The height sensors are primarily used to interpolate the magnetic propulsion field intensity as seen by magnetic sensors on the vehicle, for heave correction. The levitation force is fixed, (at velocity), and is not modulated as a result of height sensing. The accelerometer group also provides information that is used to verify changes in clearance from the magway, as a secondary measurement mechanism. Ice or snow build-up is not anticipated in sections of the magway that are regularly used. The heat generated by propelling the vehicle will melt both, and the turbulence caused by passing vehicles will expel loose residue.

RMB-22 (A) Strategies for determining location and frequency of crossovers will be based on traffic flow studies for complex networks, combined with vehicle and magway failure mode analysis. The purpose of a pair of crossovers is to permit traffic flowing in one direction on a section of magway to be diverted to the neighboring magway normally used for opposing traffic flow. This permits traffic to maneuver around a non-operating section of magway, at the penalty of delaying opposing traffic flow. The capability to do this is necessary to avoid complete stoppage in a single route system. Higher level re-routing alternatives are preferable, if the complexity of the network permits this option, and implementation of crossovers may be less frequent as a consequence. It is not in the scope of the concept definition to analyze complex networks, hence a complete response to this comment is not possible. Crossover design issues are being considered for the final concept definition report, permitting some evaluation of minimum distance possible between adjacent crossovers only.

RMB-23 (A) A vehicle attendant will accompany every Magneplane en route. The responsibility of the attendant is primarily to provide passenger assistance, and instruction when required. The attendant will not 'operate' the vehicle, but will have access to vehicle (and global) status. Consideration has been given to a 'red panic button' to provide an alternative to complete system failure, permitting the attendant to manually initiate the emergency braking procedure. Providing this capability has complex implications that will not be fully addressed in the report, and do not present significant deviation from the system concept whether or not this capability is finally implemented.

RRH-1 (A) Final report will clarify that --- only those areas of the magway, which will required "fencing off" for various reasons, will be protected by fencing. It is not intended to use fencing over the total length of magway, nor is it intended to cover the magway with chain link. Acoustic noise will be addressed in the final report discussion if warranted by the final concept study configuration. Ref. 5.3.10, FR.

RRH-2 (A) GPS is not intended as a "backup" for magway position sensors due to the "slow" acquisition time (12 to 24 seconds); but as a means of determining vehicle location for system "wake-up" or restart. If future technology improvements in GPS significantly reduce acquisition/re-acquisition time, then it would be considered in a "backup" role.

RRH-3 (A) The proposed GCS will be more automated than ATC, and no human-will-be-in-the-loop for control purposes. The final report will address this issue in detail. Ref. 3.2.3.a, FR.

RRH-4 (A) Frequency and power plus other link parameters will be shown in a final report analysis. Ref. 3.2.3.a.7.6, FR.

RRH-5 (A) GPS will not be used for vehicle control, and thus its response time is not included in headway calculations. (see RRH-2).

UED-1 (A) Passenger emergency egress will be addressed in the final report. Ref. 5.3.10 and drawings, FR.

UED-2 (A) Magnification factors for live loads have been included on appropriate portions of the magway.

UED-3 (A/N) Elevation views and banked cross sections will be shown. Details of reinforcing and connections are not within the scope of a conceptual report.

UED-4 (A) Mounting and alignment will be discussed further in the final report. REf. 3.2.2.c.2, FR.

UED-5 (A) Allowable tolerances will be coordinated with ride quality requirements. Ref. 3.2.2.c.2, FR.

UED-6 (A) Impact of switch cycle time was discussed on Pages 304 and 321 of the report.

UED-7 (A) Typo will be corrected: "to" should be "so".

UED-8 (N) Ground access roads may not be permitted in some environmentally sensitive areas making end-on construction desirable.

UED-9 (A) Agree that structural considerations should be considered.

UED-10 (A/N) Aluminum sheet to girder connection is shown on Figure 118, Page 200. In the next issue the drawings will be move complete, however, it must be kept in mind that detail drawings are not within the scope of this contract. Ref. drawings, FR.

UED-11 (A/N) See UED-10.

UED-12 (A) Levitation plate calculations will consider various vehicle speeds in a horizontal curve.

UED-13 (A/N) Agree with comment; however, since a magnetic switch will supersede the mechanical switch, the mechanical switch will be relegated to an appendix to the report and no further work will be done.

UED-14 (A) Lateral loads due to vehicles negotiating horizontal curves will be considered.

UED-16 (A) Rational for assumption on rock bolts was to be consistent with the Volpe National Transportation Study "Maglev Cost Estimation" dated January 1992, Page 6-122.

UED-17 (A) Conversions will be verified. Note, however, that all temperatures in this section are delta temperatures, therefore degrees C * 9/5 = degrees F.

UED-18 (N) The magway does not "bank" in the switch - the radius was chosen for the vehicle to be within the allowable lateral acceleration requirements without banking the magway.

UED-19 (A) Drainage will be discussed further in the final report. Since the propulsion windings are 1.4m wide, the trough can rotate 18° and the windings will still be in the "bottom" of the trough.

UED-20 (A) This 1.11m "gap" is actually a fixed section of magway which would include propulsion windings.

UED-21 (A) Please clarify "SOW supplemental wind requirements". Wind analysis was consistent with the instructions of the COTR.

UED-22 (A) Will be clarified; 3.2.2.a.1 should read spans <u>between</u> two columns.

UED-24 (A) As stated in the review, calculations subsequent to the issuance of the report have verified that the plate thickness is "OK". The final report will state this.

UED-25 (A/N) Mechanical switch will be relegated to an appendix. Adjustment is accomplished with extendable tongue.

UED-26 (N) Section 3.2.1.d.1 discusses minimum headway - headway at an active mechanical switch would be greater. (Headways need not be uniform throughout entire route.)

UED-27 (A) Tunnel size will vary according to each site. The methodology and an example will be given in the Parametric Performance Report.

UED-28 (A) The environmental impact discussion will be completed in the final report. Ref. 5.3.8, FR.

UED-29 (A) See UED-28.

UED-30 (A) See UED-28.

UED-31 (A) See UED-28.

UED-32 (A) See UED-28.

UED-33 (A) See UED-28.

UED-34 (A) Table will be completed in the final report. Ref. 5.3.8, FR.

UED-35 (A) The energy impact section will be included in the final report. Ref. 5.3.4, FR.

UED-36 (A) Cost estimates were made available at the June 4 and 5 meeting.

UED-37 (A) Will replace "levelized" with "annualized". Ref. 5.3.12, FR.

UED-38 (A) Typo will be corrected: $D \pm E_L$, $D \pm E_L$. Basis for criteria will be explained in report. Dynamic loading is considered. Ref. Supplement C, FR.

UED-39 (A) Dynamic load factor will be explained in final report. Dynamic loading from abnormal conditions are considered but would not be controlled by fatigue allowables.

UED-41 (A) Calculations will show beams will withstand crosswind. Box beams are continuous for two or four spans. Box beam deflection criteria was established prior to determination of deflections for spanning structure.

UED-42 (A) Sizes were arbitrarily selected to provide costs for a range of values. The micro-pressure wave has not been considered; one would shape the end of the tunnel to make the pressure wave acceptable.

UED-43 (N) Discussion appears adequate.

UED-44 (A) Dynamics have been considered. Final report will clarify this. Ref. Supplement C, FR.

UED-45 (A) Rationale will be provided in final report. Ref. 3.2.2.a.2, FR.

UED-46 (A/N) Some additional information will be provided; however, details are not within the scope of a concept definition report. Ref. 3.2.2.c.2, FR.

UED-47 (A/N) See UED 46.

UED-48 (A) Sensitivity studies have been made for several test problems.

UED-49 (A) A concrete fabricator's input was considered in determining costs.

UED-50 (A) An aluminum fabricator's input was used to help establish aluminum costs.

UED-51 (A) Vehicle costs were provided at the June 4 and 5 meeting.

UED-52 (A) The cost of the mechanical components of the switch is approximately $3 million. At low speeds the landing gear will be fully extended to permit maneuvering on a flat surface. In a crossover it is correct that no "tangent" section is required between the switch components, however, Figure 122 presently shows a 1.11 meter fixed section.

UED-53 (A) LSM costs were presented at the June 4 and 5 meeting.

UED-54 (A) Costs were presented at the June 4 and 5 meeting.

UED-55 (A) O&M costs will be in the final report. Ref. 5.3.12, FR.

UED-56 (A) Magway costs will be coordinated in the final report. Ref. 5.3.12, FR.

Further clarification of FAA-32

1. Comment

Peak thrust does not occur at $\alpha = 0$.

Response

Refer to the attached phasor diagram. R is neglected. α and δ are related by the following expression

$$\sin\delta = \frac{IX\cos\alpha}{V} \quad (1)$$

Substituting into the reviewer's equation (2) yields

$$P = \frac{EV}{X}\sin\delta$$

$$= \frac{EV}{X}\frac{IX\cos\alpha}{V}$$

$$= EI\cos\alpha \quad (2)$$

which shows that peak thrust is achieved at $\delta = 0$ when E and I are held constant.

The relationship in our equation (1) above also reconciles the apparent contradiction in the reviewer's equations (3) and (4). The contradiction occurs because V, I and E are not all independent of δ.

The design problem is viewed as if E and I were the independent quantities, rather than E and V which are usually assumed constant from the viewpoint of motor application.

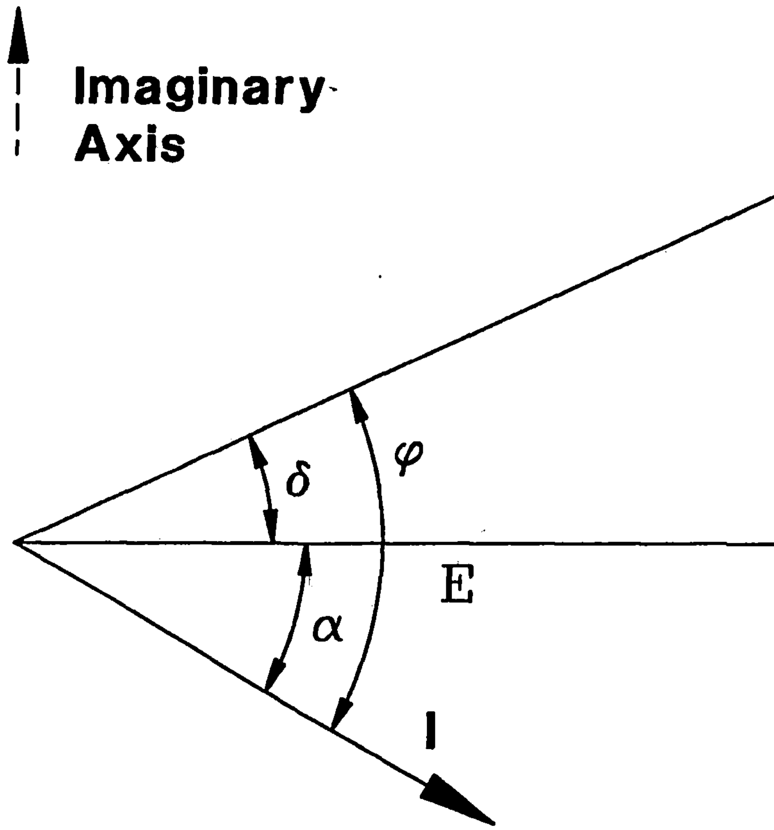
2. Comment

An operating point within a leading power factor should be selected.

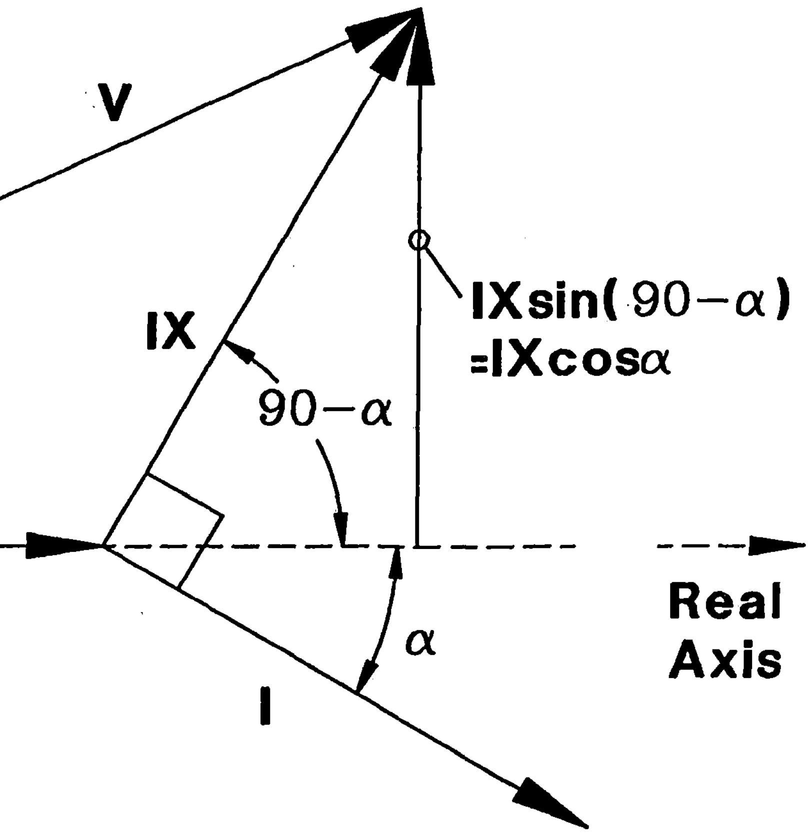
Response

Power factor was improved by increasing propulsion coil ampere-turns during design changes after the first IPR.
Further increases will be accompanied by several negative effects:

1. A slight increase in magnet weight
2. A significant increase in shielding coil weight
3. An increase in shielding coil power
4. An increase in weight of the pick-up coil for on-board power.
5. Increased vehicle weight, drag and propulsion current as a result of the above.



Imaginary Axis
δ
φ
E
α
I


V
IX
IXsin(90−α)
=IXcosα
90−α
α
I
Real
Axis

Comments & Questions Regarding the
Magneplane Team's Draft Final SCD
Maglev Report
Donald M. Rote
5/30/92

Q. Pg. 1, Some of the "design goals" listed do not correspond to contract requirements. #2, #4, #5, #6, & #8. How does attempting to meet these additional requirements impact on the effort to meet the contract requirements? MI-1 (A)

C. Pg. 4, last P, "8 degrees Kelvin" should read 8 K. MI-2 (A)

Q. What are the wt & energy penalties of using air-lubricated landing pads in lieu of wheels? MI-3 (A)

C. Pg. 13, Last P, "These fields are DC fields" assumes that there are no harmonics present. FAA-1 (A)

Q. Are harmonics of the fundamental frequency of excitation present in the stator windings? FAA-2 (A)

Q. Pg. 84, Wayside converter efficiency is stated as 95%. That seems high. What is the basis for that value? FAA-3 (A)

Q. Pg. 86, Fig 54, the landing gear friction is shown as independent of velocity. I would have expected some velocity dependence. What is the basis for the result shown? MI-35 (A)

Q. Pg. 87, What does "f_{em}" stand for? FAA-4 (A)

Q. Pg. 87, What is the range of validity of the expression given for FL/FD? FAA-5 (A)

Q. Pg. 88, Does the total drag include a term for power pickup? FAA-6 (A)

C. Pg. 89, Condition 1, item 2, regarding EM drag: the statement regarding EM drag requires further explanation. As the magnets deviate from the symmetry position, the lift, drag, and guidance forces all change in a complex way. It is not immediately obvious what will happen to the drag, in particular. FAA-7 (A)

Q. Pg. 91, Fig 57, suggests an imbalanced payload. Does this mean that the guidance force must continuously act to overcome this rotational torque? MI-4 (N)

Q. Pg. 97, 2nd line, If the emergency skids are not articulated, how will they work on both curved and flat surfaces? On pg. 114 it is said that the mechanism is identical to the take off and landing pad mechanism. Does this mean that it is articulated? MI-5 (A)

Q. Pg. 112, Fig 64, What are the units? MI-6 (A)

Q. What is the smallest radius of curvature that the vehicles can negotiate at low speed? MI-7 (A)

Q. Pg. 171, 3.2.1.m 9.b "Contact should only occur near support plate gaps" Why? because of air leakage through the gaps? Won't such a periodic contacting and air leaking cause noise and vibration? MI-8 (A)

Donald M. Rote
5/30/92

Q. Pg. 330, 5.3.2.1.c.1.3 Have you considered using 2 small linked vehicles in place of 1 large vehicle? There may be some benefits, such as better utilization of the stator windings, less stress on the guideway, ability to negotiate smaller radius curves at low speeds. MI-9 (A)

Q. Pg. 375-380, Did you keep the conductor thickness the same for all conductor types? MI-10 (A)

Q. If you were to normalize the L/D ratios by the conductor linear mass density, they would be more near equal, with ladders probably coming out a clear winner. Is that correct? MI-11 (A)

(1)

MAY.08 '92 17:23 US ARMY ENGY DIV. HUNTSVILLE P.07

MAGLEV

PROJECT Magneplane

Site Development ☐ Electrical ☒ Safety ☐ Mechanical
Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: J. Markos
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	pg 7	Work in Progress should indicate that a system safety assurance plan has not been completed.	MI-12 (A)
2	pg 15	3.1.1.h This is rather weak. Why is clear stopping distance specified ~~to~~ as a important? What other items could be included. At least include what is stated in SOW.	MI-13 (A)
3	pg 17	3.1.2.c what about impacts (3.1.2 c of SOW)	MI-14 (A)
4	pg 17	3.1.2 e should contain text similar to 3.1.2 e of SOW. FAA doesn't address current FRA egress requirements nor others items implied in "etc." of SOW.	MI-15 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

②

MAGLEV

PROJECT Magneplane

] Site Development ☐ Electrical ☒ Safety ☐ Mechanical
] Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
] Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: S. MARKOS
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
	pg 19	3.1.3h refers back to 3.1.1.a as covering evacuation of a vehicle from a curve. However, 3.1.1a does not describe any requirements for evacuation. NOTE: 3.1.1.a pg 12 contains the following sentence at the end of the last bullet: "(2) A vehicle can exit the guideway at 3 m/s." What does this mean??	MI-16 (A)
	pg 90	3.2.c.1 last paragraph. last sentence only "the forward part of the vehicle shall be protected from bird strikes" What about other kinds of impacts on the forward part of the vehicle AND birds and other kinds of impacts? Also the drawing on pg 92 seems to indicate no operator. So why forward protection needed?	MI-17 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAY.08 '92 17:29 US ARMY ENGY DIV. HUNTSVILLE P.07

(3)

MAGLEV

PROJECT Magneplane

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [x] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ______

NAME: S. MARKOS
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
7	pg 90	Nomex is indicated as to be used for honeycomb core. This would meet FRA Fire Safety Guidelines. FRA guidelines should be referenced as a minimum requirement for vehicle components	MI-18 (N)
8	pg 98	Are the requirements in 25.561 too stringent considering that a plane normally operates at a height much greater than a maglev train? Or is 25.561 directed at protecting passengers at speeds below 300 mph i.e. just before landing on runway? What are cost implications? This cost related comment also applies to other sections of Part 25 as listed in 3.2.1c	MI-19 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAY.08 '92 17:29 US ARMY ENGY DIV, HUNTSVILLE P.07

MAGLEV

PROJECT Magneplane

[ ] Site Development [ ] Electrical [X] Safety [ ] Mechanical
[ ] Architectural [ ] Instr. & Controls [ ] Advance Tech. [ ] Aerodynamics
[ ] Structural [ ] Magnetics [ ] Estimating [ ] Other ______

NAME: S. Montos
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
9	Pg 98	why not use 25.843 as a test reqmt for pressurized cabins?	MI-20 (N)
10	Pg 108	what kind of fuel tanks will there be on vehicle? to meet 25.963	MI-21 (A)
11	Pg 109	3.2.1.c.5 This is too vague! Should refer to ADA provisions which cover persons other than those who use wheelchairs.	MI-22 (A)
12	Pg 134	3.2.1g how long does the battery backup system provide power for?	MI-23 (A)
13	Pg 158	3.2.1k14 Audio is included in the title but is not discussed in text. (Is Audio meant to imply voice?)	MI-24 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

(5)

MAGLEV

PROJECT Magneplane

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [x] Safety
- [ ] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other ______

NAME: S. MARKOS
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
4	Pg 239	3.2.2.4 Chain link fencing is indicated as enclosing the entire guideway. What are EMI hazards? What are cost implications?	MI-25 (A)
5	Pg 239	3.2.2.j. does not discuss guideway evacuation (SOW 3.2.2 j)	MI-26 (A)
6	Pg 314	Reliability and Operation & Maintenance Plans have not been completed.	MI-27 (A)
7	Pg 402	The top of what's on pg. 403 should be included following 5.3.4.2.	MI-28 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

(6)

MAGLEV

PROJECT Magneplane

[ ] Site Development [ ] Electrical [X] Safety [ ] Mechanical
[ ] Architectural [ ] Instr. & Controls [ ] Advance Tech. [ ] Aerodynamics
[ ] Structural [ ] Magnetics [ ] Estimating [ ] Other ______

NAME: S. Markos
ORGANIZATION: VNTSC
DATE: 6-2-92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
8	Pg 402	5.3.10.0 Item 5 should include safety and warning devices and special procedures/training	MI-29 (A)
9	Pg 403	No mention of hazard probabilities. Use MLD-STD 882B?	MI-30 (A)
20	Pg 404	5.3.10.02 a,b Item 2 Failures should not be the only hazard category included in scope or criteria	MI-31 (A)
21	Pg 406	Guideway emergency access egress points should be added to 5.3.10.0.3	MI-32 (A)
22	Pg 410	Fire & Evacuation are major items not completed	MI-33 (A)
23	entire 5.3.10	Needs major work to be acceptable	MI-34 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

Magneplane International, Inc.
Jet Aviation Terminal, Hanscom Field West
Bedford, Massachusetts 01730
phone: 617 274 8750; fax: 617 274 8747

16 July 1992

Responses to COE comments on the Draft System Concept Definition Report

- SECOND SUBMITTAL -

Organized alphabetically and numerically
Referenced on the Design Review Comments sheets

FAA-1 (A) The assumption is reasonable with respect to ac field components from harmonics. There are two reasons:

1. Space harmonics of the LSM winding are almost non-existent, due to the pole pitch and gap.
2. Current harmonics from the converter are low in PWM converters and will be further reduced by filtering.

FAA-2 (A) See answer to question 1 above.

FAA-3 (A) The ABB bulletin states 99% efficiency at rated load for the converter alone. We use 95% to allow for transformers, etc.

FAA-4 (A) f_{em} refers to the expression for Electro-Magnetic drag in Mode II.

FAA-5 (A) The expression is accurate to about 1% over the range 5 - 150 m/s.

FAA-6 (A) No. It is on the order of 1,000 N at design speed.

FAA-7 (A) A more detailed analysis will be included in the final report. Ref. 5.3.2.21, FR.

MI-1 (A) Improving the system performance specification to improve the Magneplane's ability to penetrate the transportation market has had no significant impact on the effort required to address the goals of the SOW.

MI-2 (A) Will correct in final report.

MI-3 (A) The frictional drag due to the air lubricated pads at low speed is expected to be less than 5% of the vehicle weight (30,000 N for the 140 passenger vehicle). At very low speeds this accounts for most of the total drag. At speeds from 20 to 50 m/s the portion of the vehicle weight supported by the pads descreases as the magnetic levitation increases. The portion of total drag due to the pads varies from 40% to less than 20% in this operating region.

The weight of the air pads and deployment system will be similar to conventional landing gear of similar specification. A discussion of the air pad vs. wheels will be included in the final report. Ref. 5.3.7.a.2, FR.

MI-4 (N) The payload is balanced.

MI-5 (A) The emergency brake surface will be articulated to conform to a curved or flat guideway segment.

MI-6 (A) Pounds. This table will be labeled and listed in kg for the final report.

MI-7 (A) On a flat guideway surface the vehicle may be pivoted about its landing gear. At very low speed on a flat guideway a radius of 50m is achievable.

MI-8 (A) Yes. There will be some noise and vibration when the vehicle operates on its landing gear, similar to aircraft taxiing operations.

MI-9 (A) Yes. The concept of smaller linked vehicles was rejected due to the dynamic problem of trying to coordinate the operation of aerodynamic control surfaces on separate vehicles that are coupled in a complicated way to multiple magnet bogies. It is not obvious that there is any perceivable improvement of stator winding utilization or in ability to negotiate curves at low speed with linked vehicles.

MI-10 (A) This question will be addressed in the final report.

MI-11 (A) This question will be addressed in the final report.

MI-12 (A) The Safety Plan will be completed in the final report.

MI-13 (A) Section 3.1.1.h will be updated in the final report.

MI-14 (A) Section 3.1.2.c will be updated in the final report. The vehicle description will also address crashworthiness criteria.

MI-15 (A) Section 3.1.2.e will be updated in the final report. We are not clear on the meaning of "etc." The SOW does not specify the use of FRA requirements as the basis of a safety plan.

MI-16 (A) Section 3.1.3.h and 3.1.1.a will be updated in the final report.

MI-17 (A) 3.2.1.c.1 will include discussion in the final report of other kinds of impacts with the front of the vehicle. As noted in your comment no. 3 the protection of the forward part of the vehicle is required by the SOW 3.1.2.c.

MI-18 (N) There is no requirement in the statement of work to use the FRA fire guidelines as opposed to the FAA guidelines.

MI-19 (A) Magneplane will make efforts to evaluate potential cost savings if different emergency conditions are specified. A thorough analysis of the FRA vs. FAA safety guidelines is outside of the scope of work.

MI-20 (N) Magneplane does not understand this comment/question.

MI-21 (A) The preliminary design of the vehicle called for LNG fired APU for on-board power. This proposal has been replaced with an inductive power pick-up so that there will no longer be on-board fuel.

MI-22 (A) The provisions of the ADA are being reviewed and will be addressed in the final report. Ref. 3.2.1.c.8, FR.

MI-23 (A) The battery operating times are tabulated on pages 133 and 134 (see row "battery running time").

MI-24 (A) The title of section 3.2.1.k.14 will be clarified in the final report. Ref. 3.2.1.k.15, FR.

MI-25 (A) Guideway integrity assurance will be addressed in the final report. The EMI hazard of a chain link fence will be discussed. The cost of the integrity scheme will be included. Ref. 3.2.2.i, FR.

MI-26 (A) Guideway evacuation will be addressed in the Safety Plan in the final report. Ref. 5.3.10, FR.

MI-27 (A) Reliability, Operation and Maintenance Plans will be submitted in the final report. Ref. 3.2.3.h and 3.2.3.i, FR.

MI-28 (A) Both the Test Plan and Safety Plan will be updated in the final report. Ref. 5.3.9 and 5.3.10, FR.

MI-29 (A) The updated Safety Plan will include discussion of safety and warning devices and special procedures/training. Ref. 5.3.10, FR.

MI-30 (A) Hazard probabilities are being worked out. MLD-STD 882 B has been reviewed. Discussion will be included in the final report. Ref. 5.3.10, FR.

MI-31 (A) Section 5.2.10.0.2.b will include discussion of other hazard categories besides failures. Ref. 5.3.10, FR.

MI-32 (A) See comment MI-26.

MI-33 (A) Fire and evacuation will be addressed in the Safety Plan to be submitted in the final report. Ref. 5.3.10, FR.

MI-34 (A) Comment acknowledged.

MI-35 (A) The landing gear friction is given as an upper limit based on the known properties of the proposed pad material. With air lubrication the friction is expected to be less. The velocity characteristics for this low friction material have not been measured in the ranges of 20 to 50 m/s. Thourough characterization of the skid material properties is an objective of the test plan.

MAGLEV

PROJECT Magneplane Hypothetical Route Report

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☒ Advance Tech. ☐ Aerodynamics
☐ Structural ☐ Magnetics ☐ Estimating ☐ Other ______

NAME: John Potter
ORGANIZATION: CEHND-ED-SY
DATE: 7 Aug 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	p. 4 1.2.	This list does not match the text and figures (1, 9, 11 and 14).	A-1 (A)
2.	p. 32 3.3.2	Is a sine curve more gentle than a parabola, the standard civil layout technique?	A-2 (A)
3.	p. 35 last para	How frequently will this occur, say on the SST or Tampa-Orlando?	A-3 (A)
4.	p. 36 3.5.2	Are the controlling parameters flagged and available for analysis? If so, what are they?	a-4 (A)
5.	p. 38 3.6.2	Address the additional headway component in the neighborhood of switches, to allow for lead-vehicle deceleration to turnout speed and switch cycle time.	A-5 (A)
6.	p. 41 3.8	Complete,	A-6 (A)
7.	p. 45 4.3.4	Roll acceleration is not limited by roll rate, in general. Explain that roll acceleration is limited as implemented by Magneplane.	A-7 (A)
8.	p. 45 4.3.4	Describe how the control system will anticipate and limit roll acceleration over the "step".	A-8 (A)
9.	p. 56 3.2	This paragraph says that little of the total power required (7.1%) comes from the grid and that almost all regenerated power (93.1%) goes back into the grid. Even for an ideal system, with no losses, these two numbers together cannot exceed 100%. Rewrite this paragraph for clarity and check the values.	A-9 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

MAGLEV

PROJECT Magneplane Hypothetical Route Report

- [ ] Site Development
- [ ] Architectural
- [ ] Structural
- [ ] Electrical
- [ ] Instr. & Controls
- [ ] Magnetics
- [ ] Safety
- [x] Advance Tech.
- [ ] Estimating
- [ ] Mechanical
- [ ] Aerodynamics
- [ ] Other

NAME: John Potter

ORGANIZATION: CEHND-ED-SY

DATE: 7 Aug 92

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
10.	p. 1 Ride Quality & Dynamic Simulation	70 dBA is inconsistent with 4.5.2 Noise, p. 54.	A-10 (A)
11.	p. 1 Ride Quality & Dynamic Simulation	Are these plots for the worst seat or for the center as given in 4.1 and 4.2, p. 42?	A-11 (A)

ACTION CODES:
A - ACCEPTED/CONCUR   N - NON-CONCUR   W - WITHDRAWN

REB

I.S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT MAGLEV-MAGNEPLANE (8-12, 14 AUG 92)

☐ XX SITE DEV & GEO TECH ☐ ENVIR PROT & UTIL ☐ ARCHITECTURAL ☐ STRUCTURAL ☐ MECHANICAL ☐ MFG TECHNOLOGY ☐ ELECTRICAL ☐ INSTR & CONTROLS ☐ SAFETY ☐ ADV TECH ☐ ESTIMATING ☐ SPECIFICATIONS ☐ SYSTEMS ENG ☐ VALUE ENG ☐ OTHER

REVIEW HYPOTHETICAL ROUTE REPORT TYPE

DATE 13 AUG 92

NAME DARBY/kp

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	General	In the final version of the hypothetical route report provide every deliverable as specified in paragraph 4.0, section C of the RFP.	B-1 (A)
2.	General	Provide maximum deviation from the specified path occurring at each horizontal curve.	B-2 (A)
3.	General	Describe the assumptions used to analyze the impact of the tunnel on the performance profiles.	B-3 (A)

ACTION CODES:
A — ACCEPTED/CONCUR
D — ACTION DEFERRED
W — WITHDRAWN
N — NON-CONCUR
VE — VE POTENTIAL/VEP ATTACHED

U.S. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT: MAGLEV MAGNEPLANE HYPOTHETICAL ROUTE REPORT (8- 12, 14 Aug 92)

☒ SITE DEV & GEO TECH ☐ ENVIR PROT & UTIL ☐ ARCHITECTURAL ☐ STRUCTURAL ☐ MECHANICAL ☐ MFG TECHNOLOGY ☐ ELECTRICAL ☐ INSTR & CONTROLS ☐ SAFETY ☐ ADV TECH ☐ ESTIMATING ☐ SPECIFICATIONS ☐ SYSTEMS ENG ☐ VALUE ENG ☐ OTHER

REVIEW TYPE: Draft
DATE: 13 Aug 92
NAME: Dohrman/kp

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1.	Pg 38	Equation for required head way shows velocity divided by two times acceleration. It is not apparent why the factor two is included. Since this the effect of reducing headway time below stopping time. (Stopping time from 134 M/S at 4.9 M/S² is 27.35 s, versus the 20 s headway allowed). Clarify.	C-1 (A)
2.	Pg 45, para 4.3.5	Although it may be scientifically correct to include the effect of gravity in stating vertical accelerations, the RFP stated acceleration limits in terms of the deviation from gravity. To facilitate comparison of your report with RFP requirements, please state vertical accelerations in terms of deviation from gravity.	C-2 (A)

ACTION CODES:
A — ACCEPTED/CONCUR
D — ACTION DEFERRED
W — WITHDRAWN
N — NON-CONCUR
VE — VE POTENTIAL/VEP ATTACHED

CEHND FORM 7 (Revised) PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE

MAGLEV

PROJECT MAGNEPLANE SCD CONCEPT DWGS CN8-12(s:14 Aug 92)

☐ Site Development ☐ Electrical ☐ Safety ☐ Mechanical
☐ Architectural ☐ Instr. & Controls ☐ Advance Tech. ☐ Aerodynamics
☒ Structural ☐ Magnetics ☐ Estimating ☐ Other

NAME: Hasse/lj/205-955-3934
ORGANIZATION: CEHND-ED-CS
DATE: 11 Aug 1992

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	DWG S-2	Expansion joints would be required at every column and not as shown on drawing.	D-1 (A)
2	DWG S-2	Expansion joint detail is repeated on S-6.	D-2 (A)
3	DWG S-9	This drawing requires further explanation and clarification.	D-3 (A)
4	GENERAL	Drawing numbers should be consistent between disciplines and continuous.	D-4 (N)
5		Include drawings of switch concept.	D-5 (A)

ACTION CODES:
A - ACCEPTED/CONCUR N - NON-CONCUR W - WITHDRAWN

THRU: ED-ES (Service Branch) TO: PM (Suever)

. ARMY ENGINEER DIVISION HUNTSVILLE — CORPS OF ENGINEERS

SIGN REVIEW COMMENTS

PROJECT Magneplane Hypothetical Route Report, MAGLEV C.N. 8-12

☐ SITE DEV & GEO TECH ☐ MECHANICAL ☐ SAFETY ☐ SYSTEMS ENG
☐ ENVIR PROT & UTIL ☐ MFG TECHNOLOGY ☐ ADV TECH ☐ VALUE ENG
☐ ARCHITECTURAL ☐ ELECTRICAL XX ESTIMATING ☐ OTHER
☐ STRUCTURAL ☐ INSTR & CONTROLS ☐ SPECIFICATIONS

REVIEW TYPE N/A
DATE 14 Aug 92
NAME Young

M	DRAWING NO. OR REFERENCE	COMMENT	ACTION
		CEHND-ED-ES, Cost Engineering Branch, has reviewed this submittal and has the following comment(s):	
		The MAGLEV capital and O&M cost model developed by Volpe National Transportation compiled good cost information in preparing their cost estimates. Their report has provided a good reference for studying the economic feasibility of a MAGLEV system in the United States.	E-1 (A)

92 13:43

ACTION CODES:
A — ACCEPTED/CONCUR
D — ACTION DEFERRED
W — WITHDRAWN
N — NON-CONCUR
VE — VE POTENTIAL/VEP ATTACHED

U. S. ARMY ENGINEER DIVISION HUNTSVILLE 93 CORPS OF ENGINEERS

DESIGN REVIEW COMMENTS

PROJECT CN 8-12 Maglev Magneplane Hyp. Route Report

- ☐ SITE DEV & GEO
- ☐ ENVIR PROT&UTIL
- ☐ ARCHITECTURAL
- ☐ STRUCTURAL
- ☐ MECHANICAL
- ☐ MFG TECHNOLOGY
- ☒ ELECTRICAL
- ☐ INST&CONTROLS
- ☐ SAFETY
- ☐ ADV TECH
- ☐ ESTIMATING
- ☐ SPECIFICATIONS
- ☐ SYSTEMS ENG
- ☐ VALUE ENG
- ☐ OTHER

REVIEW Final
DATE 8-17-92 TYPE
NAME Ken Shaver/ (205)955-5346/ ED-ME

ITEM	DRAWING NO. OR REFERENCE	COMMENT	ACTION
1	P.56	Refer to Paragraph B.2, Efficiency. The Efficiency, as stated, is wrong, since it must be higher than 07.1%. Please correct the typographical error.	F-1 (A)
2	P.56	Refer to paragraph b.3. Define or describe "low R winding".	F-2 (A)
3	Sheet 8	Refer to the electrical cost estimate. The AC/AC inverters (for on board power) have not been included in the cost estimate. Please resolve the conflict.	F-3 (A)
4	Sheet 8	Refer to the cost estimate. The line "3-1/C 500 MCM, 15 KV triplex is garbled. From the 53,400 lf vs. the $28.00 unit cost, it appears that the length is for 1/c and the price is for installed triplex. Review for accuracy and also state if cable is to be CU or AL.	F-4 (A)
5	Sheet 8	The 200 ft. of cable tray is too short to be run along the guideway. Verify that a raceway system is priced or guideway distribution of the 500 MCM triplex.	F-5 (A)

ACTION CODES:
A - ACCEPTED/CONCUR
D - ACTION DEFERRED
W - WITHDRAWN
N - NON-CONCUR
VE - VE POTENTIAL/VEP ATTACHED

CEHND FORM 7 (Revised)

PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE

M E M O R A N D U M

TO: R. Suever

FROM: F. Raposa

DATE: August 14, 1992

SUBJECT: Review Comments of Magneplane Draft Hypothetical Route Report

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The intent of these comments is to identify additional data needed or to identify apparent discrepancies of the subject draft report.

I. Page 13, Fig 6. The power factor compensation capacitors shown in the figure should be discussed. The following questions should be answered:

G-1(A) 1. What is the rationale for 2 capacitors in parallel with one being capable of being switched in and out of the circuit?

G-2 (A) 2. What are the values of the capacitors? Are their values tailored for the expected frequency (or speed) of the specific route location? If so, has the cost and performance impacts been considered for operating speeds other the expected speed?

II. Page 14, Fig 7. The leapfrogging concept described appears to require about 2000 m of feeder cable per LSM blocklength connection. The cost tables (e.g. Sheet 8, WBS 1523) show that they have been accounted for. On page 40, the formula for calculating power losses identifies only the LSM stator winding losses and not the additional losses caused by the feeder cable. These cables also require additional reactive power from the system. The following questions should be answered:

G-3 (A) 3. Have the power losses of the feeder cable been accounted for?

G-4 (A) 4. What is the resistance and inductance of the feeder cables?

III. Page 17, Drawing 6869.001-E6. The 34.5 kVac distribution system appears to be a continuous system being fed by the substations at the utility connection points. Regeneration is being considered and apparently was used as a cost credit in the costs of electrical energy on the SST analysis. The following questions should be answered:

G-5 (A) 5. What is the capital cost impact to the frequency converters for having bilateral power flow capability?

G-6 (A) 6. If regeneration power is to be fed back into the utility and if the 34.5 kVac distribution system exists as a continuous system as discussed above, what is the protection against this distribution system being a back feed for utility power?

G-7 (A) 7. If a back feed condition exists, that is the 34.5 kVac system being in parallel with the utilitiy's own transmission system, will this be acceptable to a utility?

IV. Feeder cable votage rating as shown in Cost Estimation Sheets. Sheet 8 for example shows the feeder cable votltage rating to be 15 kV. Data from the previous IPRs showed that the LSM coil-to-coil voltages could approach 18 kV for the condition of uncompensated power factor (Figure 132, Draft Concept Definition Report).

G-8 (A) 8. Is the 15 kV rating for the cables going to be adequate?

G-9 (A) 9. What is the expected lifetime of these cables if they are going to operate at voltage levels that could exceed their ratings?

Review of the MAGNEPLANE SST analysis report.

By: Ray Wlodyka

H-1 (A) Magneplane provided a good description of the factors and equations that were used in conducting their analysis. The analysis of the power distribution and conversion system has been done at a high level of detail.

H-2 (A) The figures on page 5 and 6 need either table or figure nos.

H-3 (A) Where is the MIN-S ride comfort described. (not on page 4). The report goes into more ride configurations than called for. Magneplane should include a section describing each ride quality presented with a rationale for why it was included. Particularly the Orlando-Tampa route which is beyond the scope of this contract.

H-4 (A) What is the schedule for finishing the sections noted as incomplete?

H-5 (A) On page 18, Fig. 10 is MIN-B not MIN-S.

Magneplane International, Inc.
Jet Aviation Terminal, Hanscom Field West
Bedford, Massachusetts 01730
phone: 617 274 8750; fax: 617 274 8747

9 September 1992

Responses to COE comments on the Draft Hypothetical Route Report

Organized alphabetically and numerically
Referenced on the Design Review Comments sheets

A-1 (A) This will be edited for the final report.

A-2 (A) Yes, a sine curve is more gentle than a parabola. A parabola distributes the vertical acceleration over a longer period and concentrates the jerk in a pulse at each end. Mathematically, the jerk on entering a parabolic vertical curve is infinite, because a state of zero vertical acceleration changes instantly to a state of maximum vertical acceleration. A sine curve, on the other hand, is entered at the inflection point, where veritcal acceleration is zero, and the acceleration goes up gradually towards the center of the curve where it is highest. This effect is overlooked for highway layouts since the scale involved makes the effect unnoticeable for drivers. However, for maglev, it cannot be overlooked.

A-3 (A) This never occurs on the routes studied. It would rarely occur on a real route; perhaps only if intentionally built into an extremely hilly environment.

A-4 (A) Every point on the route has an independent reason for its particular velocity limit. The overwhelming majority of points are limited based on the limit of longitudinal acceleration. Points in curves are generally limited by roll angle, roll rate, vertical acceleration, or vertical jerk. In fact, all limits are considered for each point, and the limit that happens to evaluate to the lowest value becomes the "controlling parameter." The software does not store the controlling parameter for later analysis at this time; however, it is a simple addition, and it will be made in the next phase.

A-5 (N) There are no switches in the Severe Segment Test; therefore switch-related headway will not be included in the analysis. The topic is discussed in the Concept Definition Report section 3.2.3.j.

A-6 (A) Section will be completed.

A-7 (A) The section was meant to demonstrate that that the limits on roll acceleration given in the SOW would never be broken if the limit on roll rate was maintained. It was not meant to show any natural relationship between roll acceleration and roll rate.

A-8 (A) The aerodynamic control system will anticipate the "step", and all other magway features through the use of a globally-stored magway map, which is transmitted to the vehicle in short segments as required. The aerodynamic surfaces can then give the vehicle a starting push to maintain LSM alignment when entering a curve. If no aerodynamic control is used, the vehicle will experience a slight roll lag with respect to the magway centerline. Prototype testing is required to determine the requirements for and the applicability of this option.

A-9 (A) There was a typographical error in the draft. "07.1" should read "107.1".

A-10 (A) Interior noise will be kept *below* 75 dBA as required by SOW. 70 dBA was assumed at this stage in the absence of a detailed vehicle interior design.

A-11 (A) The plots in the final report are for worst seat location (ISO) and for center seat (Peplar), as required by SOW.

B-1 (A) Section 1.2. of the final report lists the sections where each of the SOW requirements are discussed.

B-2 (A) The maximum deviation, or "throw" is included in appendix F of the final report.

B-3 (A) Zero performance impact was assumed for the tunnel in the Severe Segment Test. The actual impact will be insignificant, as shown in the Concept Definition Report, section 5.3.2.2.h.

C-1 (A) It is true that the stopping time is greater than the headway time. Do not confuse these two very different measures. The amount of time it takes to stop is always greater than the amount of time it would take to go the same distance at a constant speed. For example, if you are driving and you approach a red light, you slow down and come to a stop. Let's say that just as you stop, the light turns green. Would it have been wise to keep going at a constant speed if you had previous knowledge that the light would turn at that moment? No, because if you had not stopped, you would have reached the red light earlier, and it would not have turned green just as you arrived. This could be very dangerous. Thus you should not confuse headway time with stopping time.

C-2 (A) The quantities will also be given in "g" pseudo-units.

D-1 (A) This will be clarified on the final drawings.

D-2 (A) A cross reference will be added to drawing S-6.

D-3 (A) Notes will be added for clarification.

D-4 (N) We disagree.

D-5 (A) Magswitch and crossover drawings have been added: S-10, S-10A, and S-10B.

E-1 (A) Comment acknowledged.

F-1 (A) See response A-9.

F-2 (A) A low-R winding is a winding which has half the resistance of the baseline winding.

F-3 (A) The converters will be included in the final estimate.

F-4 (A) The cable is 3-1/c triplex, copper. The unit cost of $28.00 is correct for an installed triplex. The length was incorrect and will be changed to 30,000 lf.

F-5 (A) The 200 ft. of cable tray is incorrect and will be changed to 15,000 lf.

G-1 (A) A fixed single capacitor scheme allows operation over a limited speed range. A two value scheme allows some range of operation for the LSM and was used to provide approximate cost data. An adjustable capacitor using the principle of the static VAR compensator is needed for wide speed range operation and will be described in the final report.

G-2 (A) A capacitance of 200 μF was selected for operation near design speed. This corresponds to a 60 Hz rating of 14.4 MVAR per phase at 13.8 kV. An additional switched set of capacitors of the same values and switching breaker was included to make the cost estimate more realistic.

G-3 (A) The LSM winding inductance is 14.2 mH, so the feeder cable inductance is clearly insignificant.

At the design point for the 140 passenger vehicle , the cable resistance reduces the LSM efficiency from 91.5 to 88%. However, we have allowed 7% loss in distribution and power conversion which is very conservative. We can still meet 85% overall efficiency.

G-4 (A) Two 500 MCM cables are used per phase. Each cable has a resistance of 0.0279 Ω/1000 ft. and a 60 Hz reactance of 0.0414 Ω/1000 ft. The equivalent resistance for a 2 km cable pair is 0.093 Ω and the equivalent inductance is 366 μH.

G-5 (A) We do not expect the system-wide capital cost impact to be significant because:

a. The "converter" consists of an ac/dc converter(rectifier), dc link, and dc/ac converter(inverter). The inverter and dc link are naturally regenerative. Full regenerative capability only requires the addition of another front-end converter and increases the cost by about 20%.

b. There are other options besides the regenerative capability when multiple converters are installed at one site. One is to tie the dc links together. Regeneration is between converters, but not back into the utility. The added cost is a small percentage of the converter cost.

G-6 (A) Bidirectional power flow is needed between converter stations and the 34.5 kV system. We do not expect power flow from the 34.5 to 115 kV systems under normal operation. Interconnections to the 115 kV utility will be designed in cooperation with the utilities and with reverse power flow protection where needed.

G-7 (A) The 34.5 kV system can represent a parallel utility bus if bidirectional capability to the 115 kV system is used. This design can only be considered with detailed consultation with the serving utilities. Power flow problems can be analyzed in the design stage and prevented by protection schemes which are presently part of utility practice.

G-8 (A) 15 kV cable was selected to provide typical impedance, resistance and cost data for the purpose of this study.

G-9 (A) The 15 kV rating was selected as typical. We do not plan to operate components (cables or otherwise) outside their ratings.

H-1 (A) Comment acknowledged and appreciated.

H-2 (A) The table in question was moved into an appendix and referred to by the appendix letter.

H-3 (A) All ride quality standards are quantified in appendix A. The three standards are given in the SOW, and no additional ride quality assumptions were made. There is no discussion or justification given for the study of each of the standards because the standards were originally made by the government as an arbitrary spread of possible scenarios of acceptable ride quality. In order to show that any ride quality standard will actually be acceptable to the public, physical tests must be performed. Preliminary tests this year (using an airplane) showed that some limits similar to the MIN-B standard were acceptable to passengers. The Orlando-Tampa route is relatively insensitive to ride quality as compared with the Severe Segment Test, so the choice of standard in that case was not an item of concern.

H-4 (A) All sections are complete.

H-5 (A) The table reads MIN-B in the final.

SUPPLEMENT A: BACKUP MATERIALS ON MAGWAY FOUNDATIONS

CONTENTS

RESPONSES TO C.O.E. COMMENTS

CALCULATION COVER SHEET

BCI JOB NUMBER 7901

CALCULATION NUMBER 1

CALCULATED BY MEP

DATE 8/92

JOB MAGNEPLANE - SYSTEM CONCEPT DESIGN (SCD)

SUBJECT FOOTER DESIGN - ALUMINUM BOX BEAM - DOUBLE GUIDEWAY

REFERENCES

FOUNDATION ANALYSIS AND DESIGN - JOSEPH E. BOWLES

ESSENTIALS OF SOIL MECHANICS AND FOUNDATIONS - DAVID McCARTHY

REMARKS

BROMWELL & CARRIER, INC.

MAG-LEV FOOTER DESIGN
BCI PROJ. NO. 7901

ALUMINUM BOX BEAM - DOUBLE GUIDEWAY
SPAN = 30.0 FEET

Assume Qa = 3.00 kip/ft2

h = 17.0 ft

All loads expressed in kips
All moments expressed in kip-feet

INPUT DATA

		c
DEAD LOAD (D)	Fy	106.00
SNOW LOAD (S)	Fy	39.40
	Mx	0.00
LIVE LOAD (L1)	Fy	55.00
	Fz	0.00
	Mx	495.00
LIVE LOAD (L2)	Fy	110.00
	Fz	0.00
	Mx	0.00
SEISMIC LOAD (lat)	Fx	11.10
DEAD	Mz	188.00
SEISMIC LOAD (lon)	Fx	11.10
DEAD	Mz	188.00
SEISMIC LOAD (lon)	Fx	6.00
VEHICLE ONE	Mz	137.00
SEISMIC LOAD (lat)	Fz	6.00
VEHICLE ONE	Mx	137.00
SEISMIC LOAD (lon)	Fx	6.00
VEHICLE TWO	Mz	137.00
SEISMIC LOAD (lat)	Fz	6.00
VEHICLE TWO	Mx	137.00
WIND LOAD (W)	Fz	16.50
	Mx	335.00
WIND ON OPERATING VEHICLE (Wv)	Fy	-2.50
	Fz	6.80
	Mx	180.00
WIND ON OPERATING VEHICLE (Wv2)	Fy	-2.50
(2nd vehicle)	Fz	6.80
	Mx	180.00
BRAKING LOAD (B)	Fx	36.00
	Mz	853.00
BRAKING LOAD (B2)	Fx	36.00
(2nd vehicle)	Mz	853.00

OUTPUT (h = 17.0 ft)

LOADING CASE	Q(Total) Fy	Mx (Total)	Mz (Total)
D	106.00	0.00	0.00
D + S	145.40	0.00	0.00
D + L1	161.00	495.00	0.00
D + L + L2	216.00	0.00	0.00
D -/+ W	106.00	335.00	0.00
D -/+ Elateral	106.00	188.00	0.00
D -/+ Elong	106.00	0.00	188.00
D + L -/+ [(30/85)^2 W + Wv1]	161.31	559.15	0.00
D + L + L2 -/+ [(30/85)^2 W + Wv1 + Wv2]	213.81	86.57	0.00
(D + L -/+ (EdeadLat + EQv1Lat)) * 0.75	120.75	615.00	0.00
(D + L + L2 -/+ (Edead + EQv1LAT + EQv2LAT)) * 0.75	162.00	346.50	0.00
(D + L -/+ Edead + EQv1long) * 0.75	120.75	371.25	243.75
(D + L + L2 -/+ Edeadlong + EQV1long+EQV2LONG) * 0.75	162.00	0.00	346.50
(D + L1 -/+ B) * 0.75	120.75	371.25	639.75
(D + L1 + L2 -/+ [B + B2]) * 0.75	162.00	0.00	1279.50
(D + L1 + L2 -/+ [B - B2]) * 0.75	162.00	0.00	0.00

Ex	Ez	Df	Wl (B)	Wt (L)	FOOTER AREA(ft2)	Q(min) (kp/ft2)	Q(max) (kp/ft2)
0.00	0.00	2.50	5.94	5.94	35.33	3.00	3.00
0.00	0.00	2.50	6.96	6.96	48.47	3.00	3.00
0.00	3.07	2.50	6.00	18.50	111.00	0.00	2.90
0.00	0.00	2.50	8.49	8.49	72.00	3.00	3.00
0.00	3.16	2.50	5.94	14.00	83.22	-0.45	3.00
0.00	1.77	2.50	5.94	14.00	83.22	0.31	2.24
1.77	0.00	2.50	9.49	14.00	132.88	-0.10	1.69
0.00	3.47	2.50	7.33	18.50	135.66	-0.15	2.53
0.00	0.40	2.50	8.44	18.50	156.18	1.19	1.55
0.00	5.09	2.50	6.34	18.50	117.37	-0.67	2.73
0.00	2.14	2.50	7.35	18.50	135.95	0.37	2.02
2.02	3.07	2.50	8.00	18.50	148.00	-1.23	2.86
2.14	0.00	2.50	9.00	18.50	166.50	-0.41	2.36
5.30	3.07	2.50	11.00	18.50	203.50	-1.71	2.90
7.90	0.00	2.50	13.50	18.50	249.75	-1.63	2.93
0.00	0.00	2.50	7.35	18.50	135.95	1.19	1.19
FINAL DIMENSIONS			13.50	18.50	249.75		

CALCULATION COVER SHEET

BCI JOB NUMBER 7901

CALCULATION NUMBER 2

CALCULATED BY RDT

DATE 3/92 - 4/92

JOB MAGNEPLANE - SYSTEM CONCEPT DESIGN (SCD)

SUBJECT AXIAL PILE CAPACITY DESIGN: 18-INCH DIAMETER PIPE PILE AND 18-INCH SQUARE PRESTRESSED CONCRETE PILE

REFERENCES FLORIDA DEPARTMENT OF TRANSPORTATION STRUCTURES DESIGN OFFICE.
STATIC PILE BEARING CAPACITY ANALYSIS PROGRAM SPT 91 - VERSION 1.1

REMARKS

BROMWELL & CARRIER, INC.

FLORIDA DEPARTMENT OF TRANSPORTATION
STRUCTURES DESIGN OFFICE
STATIC PILE BEARING CAPACITY ANALYSIS PROGRAM
SPT91 - VERSION 1.1 JANUARY, 1992
BASED ON RESEARCH BULLETIN RB-121
"GUIDELINES FOR USE IN THE SOILS INVESTIGATION
AND DESIGN OF FOUNDATIONS FOR
BRIDGE STRUCTURES IN THE STATE OF FLORIDA"

NOTE - THIS PROGRAM IS INTENDED FOR USE WITH DRIVEN DISPLACEMENT PILES ONLY

A. GENERAL INFORMATION

INPUT FILE NAME	a:7901-2t
RUN DATE	04/07/92
RUN TIME	08:58:01
PROJECT NUMBER	7901
JOB NAME	Magneplane
SUBMITTING ENGINEER	Larry D. Madrid, PE
BORING NO.	
DRILLING DATE	
STATION NO.	
GROUND SURFACE ELEVATION	.00 FEET
TYPE OF ANALYSIS	2 - DETERMINATION OF STATIC PILE BEARING CAPACITIES FOR A RANGE OF PILE LENGTHS (CAPACITY VS. TIP ELEVATION)

Project No: 7901 Magneplane
Boring No:

B. BORING LOG

ENTRY NO.	DEPTH (FT) D(I)	ELEVATION (FT)	SPT BLOWS/FT N(I)	SOIL TYPE ST(I)
1	.0	.0	.0	2
2	5.0	-5.0	10.0	2
3	10.0	-10.0	10.0	2
4	15.0	-15.0	10.0	2
5	20.0	-20.0	10.0	2
6	25.0	-25.0	10.0	2
7	30.0	-30.0	10.0	2
8	35.0	-35.0	10.0	2
9	40.0	-40.0	10.0	2
10	45.0	-45.0	10.0	2
11	50.0	-50.0	10.0	2
12	55.0	-55.0	10.0	2
13	60.0	-60.0	10.0	2
14	65.0	-65.0	10.0	2
15	70.0	-70.0	10.0	2
16	75.0	-75.0	10.0	2
17	80.0	-80.0	10.0	2
18	85.0	-85.0	10.0	2
19	90.0	-90.0	10.0	2
20	95.0	-95.0	10.0	2
21	100.0	-100.0	10.0	2
22	105.0	-105.0	10.0	2
23	110.0	-110.0	10.0	2
24	115.0	-115.0	10.0	2
25	120.0	-120.0	10.0	2
26	125.0	-125.0	10.0	2
27	130.0	-130.0	10.0	2
28	135.0	-135.0	10.0	2
29	140.0	-140.0	10.0	2
30	145.0	-145.0	10.0	2
31	150.0	-150.0	10.0	2
32	155.0	-155.0	10.0	2
33	160.0	-160.0	10.0	2
34	165.0	-165.0	10.0	2
35	170.0	-170.0	10.0	2
36	175.0	-175.0	.0	0

Project No: 7901 Magneplane
Boring No:

SOIL TYPE LEGEND

0 - BOTTOM OF BORING
1 - PLASTIC CLAYS
2 - CLAY/SILT SAND MIXTURES, SILTS & MARLS
3 - CLEAN SAND
4 - SOFT LIMESTONE, VERY SHELLY SANDS
5 - VOID (NO CAPACITY)

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION	ISECT =	1 {square}
WIDTH OF PILE	WP =	18.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	17.64	10.50	28.14	14.07	49.14
15.0	-15.0	30.51	11.80	42.31	21.16	65.91
20.0	-20.0	43.49	12.00	55.49	27.75	79.49
25.0	-25.0	56.52	12.00	68.52	34.26	92.52
30.0	-30.0	69.56	12.00	81.56	40.78	105.56
35.0	-35.0	82.62	12.00	94.62	47.31	118.62
40.0	-40.0	95.69	12.00	107.69	53.85	131.69
45.0	-45.0	108.76	12.00	120.76	60.38	144.76
50.0	-50.0	121.84	12.00	133.84	66.92	157.84
55.0	-55.0	134.92	12.00	146.92	73.46	170.92
60.0	-60.0	148.00	12.00	160.00	80.00	184.00
65.0	-65.0	161.08	12.00	173.08	86.54	197.08
70.0	-70.0	174.17	12.00	186.17	93.08	210.17
75.0	-75.0	187.25	12.00	199.25	99.63	223.25
80.0	-80.0	200.34	12.00	212.34	106.17	236.34
85.0	-85.0	213.42	12.00	225.42	112.71	249.42
90.0	-90.0	226.51	12.00	238.51	119.25	262.51
95.0	-95.0	239.60	12.00	251.60	125.80	275.60
100.0	-100.0	252.68	12.00	264.68	132.34	288.68
105.0	-105.0	265.77	12.00	277.77	138.89	301.77
110.0	-110.0	278.86	12.00	290.86	145.43	314.86
115.0	-115.0	291.95	12.00	303.95	151.97	327.95
120.0	-120.0	305.04	12.00	317.04	158.52	341.04
125.0	-125.0	318.13	12.00	330.13	165.06	354.13
130.0	-130.0	331.21	12.00	343.21	171.61	367.21
135.0	-135.0	344.30	12.00	356.30	178.15	380.30
140.0	-140.0	357.39	12.00	369.39	184.70	393.39
145.0	-145.0	370.48	12.00	382.48	191.24	406.48
150.0	-150.0	383.57	12.00	395.57	197.79	419.57
155.0	-155.0	396.66	12.00	408.66	204.33	432.66
160.0	-160.0	409.75	12.00	421.75	210.88	445.75

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 1

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION ISECT = 1 {square}
WIDTH OF PILE WP = 24.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	23.69	18.67	42.36	21.18	79.69
15.0	-15.0	40.87	19.56	60.42	30.21	99.53
20.0	-20.0	58.18	21.27	79.45	39.72	121.98
25.0	-25.0	75.55	21.33	96.89	48.44	139.55
30.0	-30.0	92.95	21.33	114.29	57.14	156.95
35.0	-35.0	110.37	21.33	131.70	65.85	174.37
40.0	-40.0	127.79	21.33	149.13	74.56	191.79
45.0	-45.0	145.22	21.33	166.56	83.28	209.22
50.0	-50.0	162.66	21.33	183.99	92.00	226.66
55.0	-55.0	180.10	21.33	201.43	100.72	244.10
60.0	-60.0	197.54	21.33	218.88	109.44	261.54
65.0	-65.0	214.99	21.33	236.32	118.16	278.99
70.0	-70.0	232.43	21.33	253.77	126.88	296.43
75.0	-75.0	249.88	21.33	271.21	135.61	313.88
80.0	-80.0	267.33	21.33	288.66	144.33	331.33
85.0	-85.0	284.78	21.33	306.11	153.05	348.78
90.0	-90.0	302.22	21.33	323.56	161.78	366.22
95.0	-95.0	319.67	21.33	341.01	170.50	383.67
100.0	-100.0	337.12	21.33	358.46	179.23	401.12
105.0	-105.0	354.58	21.33	375.91	187.95	418.58
110.0	-110.0	372.03	21.33	393.36	196.68	436.03
115.0	-115.0	389.48	21.33	410.81	205.41	453.48
120.0	-120.0	406.93	21.33	428.26	214.13	470.93
125.0	-125.0	424.38	21.33	445.71	222.86	488.38
130.0	-130.0	441.83	21.33	463.17	231.58	505.83
135.0	-135.0	459.29	21.33	480.62	240.31	523.29
140.0	-140.0	476.74	21.33	498.07	249.04	540.74
145.0	-145.0	494.19	21.33	515.52	257.76	558.19
150.0	-150.0	511.64	21.33	532.98	266.49	575.64
155.0	-155.0	529.10	21.33	550.43	275.21	593.10
160.0	-160.0	546.55	21.33	567.88	283.94	610.55

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 2

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION ISECT = 1 {square}
WIDTH OF PILE WP = 30.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	29.72	29.17	58.89	29.44	117.22
15.0	-15.0	51.21	30.56	81.76	40.88	142.87
20.0	-20.0	72.86	31.25	104.11	52.05	166.61
25.0	-25.0	94.58	33.33	127.91	63.95	194.58
30.0	-30.0	116.33	33.33	149.66	74.83	216.33
35.0	-35.0	138.10	33.33	171.43	85.72	238.10
40.0	-40.0	159.88	33.33	193.21	96.61	259.88
45.0	-45.0	181.67	33.33	215.00	107.50	281.67
50.0	-50.0	203.47	33.33	236.80	118.40	303.47
55.0	-55.0	225.27	33.33	258.60	129.30	325.27
60.0	-60.0	247.07	33.33	280.40	140.20	347.07
65.0	-65.0	268.88	33.33	302.21	151.10	368.88
70.0	-70.0	290.68	33.33	324.02	162.01	390.68
75.0	-75.0	312.49	33.33	345.83	172.91	412.49
80.0	-80.0	334.30	33.33	367.64	183.82	434.30
85.0	-85.0	356.11	33.33	389.45	194.72	456.11
90.0	-90.0	377.92	33.33	411.26	205.63	477.92
95.0	-95.0	399.74	33.33	433.07	216.54	499.74
100.0	-100.0	421.55	33.33	454.88	227.44	521.55
105.0	-105.0	443.36	33.33	476.70	238.35	543.36
110.0	-110.0	465.18	33.33	498.51	249.26	565.18
115.0	-115.0	486.99	33.33	520.33	260.16	586.99
120.0	-120.0	508.81	33.33	542.14	271.07	608.81
125.0	-125.0	530.62	33.33	563.96	281.98	630.62
130.0	-130.0	552.44	33.33	585.77	292.89	652.44
135.0	-135.0	574.25	33.33	607.59	303.79	674.25
140.0	-140.0	596.07	33.33	629.40	314.70	696.07
145.0	-145.0	617.88	33.33	651.22	325.61	717.88
150.0	-150.0	639.70	33.33	673.03	336.52	739.70
155.0	-155.0	661.52	33.33	694.85	347.42	761.52
160.0	-160.0	683.33	33.33	716.67	358.33	783.33

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 3

Project No: 7901 Magneplane
Boring No:

FLORIDA DEPARTMENT OF TRANSPORTATION
STRUCTURES DESIGN OFFICE
STATIC PILE BEARING CAPACITY ANALYSIS PROGRAM
SPT91 - VERSION 1.1 JANUARY, 1992
BASED ON RESEARCH BULLETIN RB-121
"GUIDELINES FOR USE IN THE SOILS INVESTIGATION
AND DESIGN OF FOUNDATIONS FOR
BRIDGE STRUCTURES IN THE STATE OF FLORIDA"

NOTE - THIS PROGRAM IS INTENDED FOR USE WITH DRIVEN DISPLACEMENT PILES ONLY

A. GENERAL INFORMATION

INPUT FILE NAME	a:7901-3t
RUN DATE	03/26/92
RUN TIME	09:34:47
PROJECT NUMBER	7901
JOB NAME	Magneplane
SUBMITTING ENGINEER	Larry D. Madrid, PE
BORING NO.	
DRILLING DATE	
STATION NO.	
GROUND SURFACE ELEVATION	.00 FEET
TYPE OF ANALYSIS	2 - DETERMINATION OF STATIC PILE BEARING CAPACITIES FOR A RANGE OF PILE LENGTHS (CAPACITY VS. TIP ELEVATION)

Project No: 7901 Magneplane
Boring No:

B. BORING LOG

ENTRY NO.	DEPTH (FT) D(I)	ELEVATION (FT)	SPT BLOWS/FT N(I)	SOIL TYPE ST(I)
1	.0	.0	.0	2
2	5.0	-5.0	10.0	2
3	10.0	-10.0	10.0	2
4	15.0	-15.0	10.0	2
5	20.0	-20.0	10.0	2
6	25.0	-25.0	10.0	2
7	30.0	-30.0	10.0	2
8	35.0	-35.0	10.0	2
9	40.0	-40.0	10.0	2
10	45.0	-45.0	10.0	2
11	50.0	-50.0	10.0	2
12	55.0	-55.0	10.0	2
13	60.0	-60.0	10.0	2
14	65.0	-65.0	10.0	2
15	70.0	-70.0	10.0	2
16	75.0	-75.0	10.0	2
17	80.0	-80.0	10.0	2
18	85.0	-85.0	10.0	2
19	90.0	-90.0	10.0	2
20	95.0	-95.0	10.0	2
21	100.0	-100.0	10.0	2
22	105.0	-105.0	10.0	2
23	110.0	-110.0	10.0	2
24	115.0	-115.0	10.0	2
25	120.0	-120.0	10.0	2
26	125.0	-125.0	10.0	2
27	130.0	-130.0	10.0	2
28	135.0	-135.0	10.0	2
29	140.0	-140.0	10.0	2
30	145.0	-145.0	10.0	2
31	150.0	-150.0	10.0	2
32	155.0	-155.0	10.0	2
33	160.0	-160.0	10.0	2
34	165.0	-165.0	10.0	2
35	170.0	-170.0	10.0	2
36	175.0	-175.0	.0	0

Project No: 7901 Magneplane
Boring No:

SOIL TYPE LEGEND

0 - BOTTOM OF BORING
1 - PLASTIC CLAYS
2 - CLAY/SILT SAND MIXTURES, SILTS & MARLS
3 - CLEAN SAND
4 - SOFT LIMESTONE, VERY SHELLY SANDS
5 - VOID (NO CAPACITY)

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION ISECT = 2 {round}
DIAMETER OF PILE WP = 18.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	13.86	8.25	22.10	11.05	38.60
15.0	-15.0	23.96	9.27	33.23	16.62	51.77
20.0	-20.0	34.16	9.42	43.58	21.79	62.43
25.0	-25.0	44.39	9.42	53.81	26.91	72.66
30.0	-30.0	54.64	9.42	64.06	32.03	82.91
35.0	-35.0	64.89	9.42	74.32	37.16	93.17
40.0	-40.0	75.16	9.42	84.58	42.29	103.43
45.0	-45.0	85.42	9.42	94.85	47.42	113.70
50.0	-50.0	95.69	9.42	105.12	52.56	123.97
55.0	-55.0	105.97	9.42	115.39	57.69	134.24
60.0	-60.0	116.24	9.42	125.66	62.83	144.51
65.0	-65.0	126.51	9.42	135.94	67.97	154.79
70.0	-70.0	136.79	9.42	146.21	73.11	165.06
75.0	-75.0	147.07	9.42	156.49	78.25	175.34
80.0	-80.0	157.34	9.42	166.77	83.38	185.62
85.0	-85.0	167.62	9.42	177.05	88.52	195.90
90.0	-90.0	177.90	9.42	187.32	93.66	206.17
95.0	-95.0	188.18	9.42	197.60	98.80	216.45
100.0	-100.0	198.46	9.42	207.88	103.94	226.73
105.0	-105.0	208.74	9.42	218.16	109.08	237.01
110.0	-110.0	219.02	9.42	228.44	114.22	247.29
115.0	-115.0	229.30	9.42	238.72	119.36	257.57
120.0	-120.0	239.58	9.42	249.00	124.50	267.85
125.0	-125.0	249.86	9.42	259.28	129.64	278.13
130.0	-130.0	260.14	9.42	269.56	134.78	288.41
135.0	-135.0	270.42	9.42	279.84	139.92	298.69
140.0	-140.0	280.70	9.42	290.12	145.06	308.97
145.0	-145.0	290.98	9.42	300.40	150.20	319.25
150.0	-150.0	301.26	9.42	310.68	155.34	329.53
155.0	-155.0	311.54	9.42	320.96	160.48	339.81
160.0	-160.0	321.82	9.42	331.24	165.62	350.09

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 1

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION ISECT = 2 {round}
DIAMETER OF PILE WP = 24.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	18.60	14.66	33.27	16.63	62.59
15.0	-15.0	32.10	15.36	47.46	23.73	78.17
20.0	-20.0	45.70	16.70	62.40	31.20	95.80
25.0	-25.0	59.34	16.76	76.10	38.05	109.61
30.0	-30.0	73.01	16.76	89.76	44.88	123.27
35.0	-35.0	86.68	16.76	103.44	51.72	136.95
40.0	-40.0	100.37	16.76	117.12	58.56	150.63
45.0	-45.0	114.06	16.76	130.81	65.41	164.33
50.0	-50.0	127.75	16.76	144.51	72.25	178.02
55.0	-55.0	141.45	16.76	158.21	79.10	191.72
60.0	-60.0	155.15	16.76	171.91	85.95	205.42
65.0	-65.0	168.85	16.76	185.61	92.80	219.12
70.0	-70.0	182.55	16.76	199.31	99.65	232.82
75.0	-75.0	196.25	16.76	213.01	106.51	246.52
80.0	-80.0	209.96	16.76	226.71	113.36	260.22
85.0	-85.0	223.66	16.76	240.42	120.21	273.93
90.0	-90.0	237.37	16.76	254.12	127.06	287.63
95.0	-95.0	251.07	16.76	267.83	133.91	301.34
100.0	-100.0	264.78	16.76	281.53	140.77	315.04
105.0	-105.0	278.48	16.76	295.24	147.62	328.75
110.0	-110.0	292.19	16.76	308.94	154.47	342.46
115.0	-115.0	305.90	16.76	322.65	161.33	356.16
120.0	-120.0	319.60	16.76	336.36	168.18	369.87
125.0	-125.0	333.31	16.76	350.06	175.03	383.57
130.0	-130.0	347.02	16.76	363.77	181.89	397.28
135.0	-135.0	360.72	16.76	377.48	188.74	410.99
140.0	-140.0	374.43	16.76	391.19	195.59	424.70
145.0	-145.0	388.14	16.76	404.89	202.45	438.40
150.0	-150.0	401.84	16.76	418.60	209.30	452.11
155.0	-155.0	415.55	16.76	432.31	216.15	465.82
160.0	-160.0	429.26	16.76	446.02	223.01	479.53

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 2

Project No: 7901 Magneplane
Boring No:

C. PILE INFORMATION

TEST PILE SECTION ISECT = 2 {round}
DIAMETER OF PILE WP = 30.00 INCHES

D. PILE CAPACITY VS. PENETRATION

TEST PILE LENGTH (FT)	PILE TIP ELEV (FT)	ULTIMATE SIDE FRICTION (TONS)	MOBILIZED END BEARING (TONS)	ESTIMATED DAVISSON CAPACITY (TONS)	ALLOWABLE PILE CAPACITY (TONS)	ULTIMATE PILE CAPACITY (TONS)
10.0	-10.0	23.34	22.91	46.25	23.13	92.07
15.0	-15.0	40.22	24.00	64.22	32.11	112.21
20.0	-20.0	57.22	24.54	81.77	40.88	130.85
25.0	-25.0	74.28	26.18	100.46	50.23	152.82
30.0	-30.0	91.36	26.18	117.54	58.77	169.90
35.0	-35.0	108.46	26.18	134.64	67.32	187.00
40.0	-40.0	125.57	26.18	151.75	75.88	204.11
45.0	-45.0	142.68	26.18	168.86	84.43	221.22
50.0	-50.0	159.80	26.18	185.98	92.99	238.34
55.0	-55.0	176.92	26.18	203.10	101.55	255.46
60.0	-60.0	194.05	26.18	220.23	110.11	272.59
65.0	-65.0	211.18	26.18	237.36	118.68	289.72
70.0	-70.0	228.30	26.18	254.48	127.24	306.84
75.0	-75.0	245.43	26.18	271.61	135.81	323.97
80.0	-80.0	262.56	26.18	288.74	144.37	341.10
85.0	-85.0	279.69	26.18	305.87	152.94	358.23
90.0	-90.0	296.82	26.18	323.00	161.50	375.36
95.0	-95.0	313.95	26.18	340.13	170.07	392.49
100.0	-100.0	331.09	26.18	357.27	178.63	409.63
105.0	-105.0	348.22	26.18	374.40	187.20	426.76
110.0	-110.0	365.35	26.18	391.53	195.77	443.89
115.0	-115.0	382.48	26.18	408.66	204.33	461.02
120.0	-120.0	399.62	26.18	425.80	212.90	478.16
125.0	-125.0	416.75	26.18	442.93	221.47	495.29
130.0	-130.0	433.88	26.18	460.06	230.03	512.42
135.0	-135.0	451.02	26.18	477.20	238.60	529.56
140.0	-140.0	468.15	26.18	494.33	247.17	546.69
145.0	-145.0	485.29	26.18	511.47	255.73	563.83
150.0	-150.0	502.42	26.18	528.60	264.30	580.96
155.0	-155.0	519.56	26.18	545.74	272.87	598.10
160.0	-160.0	536.69	26.18	562.87	281.43	615.23

*** THE MAXIMUM PILE LENGTH HAS BEEN REACHED

Project No: 7901 Magneplane
Boring No:

D. PILE CAPACITY VS. PENETRATION (CONTINUED)

NOTES

1. MOBILIZED END BEARING IS 1/3 OF THE ORIGINAL RB-121 VALUES.
2. DAVISSON PILE CAPACITY IS AN ESTIMATE BASED ON FAILURE CRITERIA, AND EQUALS ULTIMATE SIDE FRICTION PLUS MOBILIZED END BEARING.
3. ALLOWABLE PILE CAPACITY IS 1/2 THE DAVISSON PILE CAPACITY.
4. ULTIMATE PILE CAPACITY IS ULTIMATE SIDE FRICTION PLUS 3 x THE MOBILIZED END BEARING.

PROBLEM COMPLETED ANALYSIS NO. 3

CALCULATION COVER SHEET

BCI JOB NUMBER 7901

CALCULATION NUMBER 3

CALCULATED BY RDT

DATE 8/92

JOB MAGNEPLANE- SYSTEM CONCEPT DESIGN (SCD)

SUBJECT LATERAL PILE ANALYSIS FOR ALUMINUM BOX BEAM DOUBLE GUIDEWAY 18-INCH DIAMETER PIPE PILE, 16-INCH SQUARE PRESTRESSED CONCRETE PILE, AND 36-INCH DIAMETER DRILLED SHAFT.

REFERENCES PROGRAM LPILE VERSION 3.0 ENSOFT, INC.

REMARKS

BROMWELL & CARRIER, INC.

DOUBLE ALUMINUM BOX BEAM GUIDEWAY
45 FT SPAN, 30 FT HEIGHT
2X2 PIPE PILE GROUP

COMPRESSIVE LOAD
(D+L+B)(.75) = 165.9 KIPS/PILE = 82.95 TONS/PILE

TENSILE LOAD
(D+L+B)(.75) = 150 KIPS/PILE = 75.4 TONS/PILE

LATERAL LOAD
DUE TO BRAKING Fz = 9 KIPS/PILE

TO ACHIEVE A AXIAL COMPRESSIVE LOAD OF 82.95 TONS/PILE, A 18" DIAMETER PIPE PILE, 1/2" THICK WALL, 80 FT LONG IS NEEDED. THIS PILE SIZE WILL ALSO ACHIEVE THE TENSILE LOAD 75.4 TONS/PILE.

THE ALLOWABLE CAPACITY OF THE PILE IS 83.38 TONS. THE ULTIMATE SIDE FRICTION IS 157.34 TONS WHICH EQUATES TO AN ALLOWABLE UPLIFT CAPACITY OF 78.67 TONS WITH A SAFETY FACTOR OF 2.

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PROGRAM LPILE Version 3.0

MAGLEV ALUM BOX BEAM DOUBLE HT 30' SPAN 45', 18" 80' PIPE PILE

UNITS--ENGLISH UNITS

I N P U T   I N F O R M A T I O N

THE LOADING IS STATIC

PILE GEOMETRY AND PROPERTIES

PILE LENGTH = 960.00 IN
2 POINTS

X	DIAMETER	MOMENT OF INERTIA	AREA	MODULUS OF ELASTICITY
IN	IN	IN**4	IN**2	LBS/IN**2
.00	18.000	.105D+04	.275D+02	.290D+08
960.00	18.000	.105D+04	.275D+02	.290D+08

SOILS INFORMATION

X AT THE GROUND SURFACE = .00 IN

2 LAYER(S) OF SOIL

```
LAYER  1
THE SOIL IS A SAND
X AT THE TOP OF THE LAYER            =        .00 IN
X AT THE BOTTOM OF THE LAYER         =      60.00 IN
MODULUS OF SUBGRADE REACTION         =   .250D+02 LBS/IN**3

LAYER  2
THE SOIL IS A SAND
X AT THE TOP OF THE LAYER            =      60.00 IN
X AT THE BOTTOM OF THE LAYER         =     960.00 IN
MODULUS OF SUBGRADE REACTION         =   .200D+02 LBS/IN**3


DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
                   4 POINTS
            X,IN     WEIGHT,LBS/IN**3
             .00        .58D-01
           60.00        .58D-01
           60.00        .22D-01
          960.00        .22D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
                   2 POINTS
            X,IN       C,LBS/IN**2      PHI,DEGREES      E50
             .00       .000D+00         .290D+02        -----
          960.00       .000D+00         .290D+02        -----
```

BOUNDARY AND LOADING CONDITIONS

```
LOADING NUMBER   1

BOUNDARY-CONDITION CODE                  =         1
LATERAL LOAD AT THE PILE HEAD            =   .900D+04 LBS
MOMENT AT THE PILE HEAD                  =   .000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD              =   .166D+06 LBS
```

FINITE-DIFFERENCE PARAMETERS

```
    NUMBER OF PILE INCREMENTS                                =        100
    DEFLECTION TOLERANCE ON DETERMINATION OF CLOSURE         =   .100D-04 IN
    MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS   =        100
    MAXIMUM ALLOWABLE DEFLECTION                             =    .18D+03 IN
```

OUTPUT CODES

```
    KOUTPT =  1
    KPYOP  =  0
    INC    =  4
```

O U T P U T   I N F O R M A T I O N
****

LOADING NUMBER 1

BOUNDARY CONDITION CODE = 1
LATERAL LOAD AT THE PILE HEAD = .900D+04 LBS
MOMENT AT THE PILE HEAD = .000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD = .166D+06 LBS

X	DEFLECTION	MOMENT	SHEAR	SOIL REACTION	TOTAL STRESS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.219D+00	-.736D-07	.900D+04	.000D+00	.603D+04	.305D+11
38.40	.138D+00	.320D+06	.601D+04	-.132D+03	.877D+04	.305D+11
76.80	.716D-01	.460D+06	.947D+03	-.110D+03	.996D+04	.305D+11
115.20	.270D-01	.432D+06	-.243D+04	-.620D+02	.973D+04	.305D+11
153.60	.282D-02	.310D+06	-.375D+04	-.865D+01	.868D+04	.305D+11
192.00	-.641D-02	.170D+06	-.337D+04	.246D+02	.749D+04	.305D+11
230.40	-.729D-02	.626D+05	-.219D+04	.335D+02	.657D+04	.305D+11
268.80	-.496D-02	.205D+04	-.100D+04	.266D+02	.605D+04	.305D+11
307.20	-.238D-02	-.199D+05	-.206D+03	.146D+02	.620D+04	.305D+11
345.60	-.683D-03	-.198D+05	.153D+03	.471D+01	.620D+04	.305D+11
384.00	.865D-04	-.121D+05	.217D+03	-.664D+00	.614D+04	.305D+11
422.40	.268D-03	-.485D+04	.152D+03	-.226D+01	.608D+04	.305D+11
460.80	.203D-03	-.654D+03	.691D+02	-.187D+01	.604D+04	.305D+11
499.20	.961D-04	.845D+03	.147D+02	-.959D+00	.604D+04	.305D+11
537.60	.247D-04	.896D+03	-.767D+01	-.265D+00	.604D+04	.305D+11
576.00	-.509D-05	.505D+03	-.106D+02	.586D-01	.604D+04	.305D+11
614.40	-.102D-04	.167D+03	-.657D+01	.125D+00	.604D+04	.305D+11
652.80	-.654D-05	-.639D+00	-.240D+01	.853D-01	.603D+04	.305D+11
691.20	-.246D-05	-.431D+02	-.150D+00	.339D-01	.604D+04	.305D+11
729.60	-.264D-06	-.326D+02	.502D+00	.385D-02	.604D+04	.305D+11
768.00	.382D-06	-.137D+02	.417D+00	-.586D-02	.604D+04	.305D+11
806.40	.334D-06	-.221D+01	.185D+00	-.539D-02	.603D+04	.305D+11
844.80	.151D-06	.160D+01	.324D-01	-.255D-02	.603D+04	.305D+11
883.20	.302D-07	.152D+01	-.229D-01	-.534D-03	.603D+04	.305D+11
921.60	-.202D-07	.513D+00	-.236D-01	.371D-03	.603D+04	.305D+11
960.00	-.438D-07	.000D+00	.000D+00	.840D-03	.603D+04	.305D+11

OUTPUT VERIFICATION

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = .552D-07 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = .375D-08 LBS

OUTPUT SUMMARY

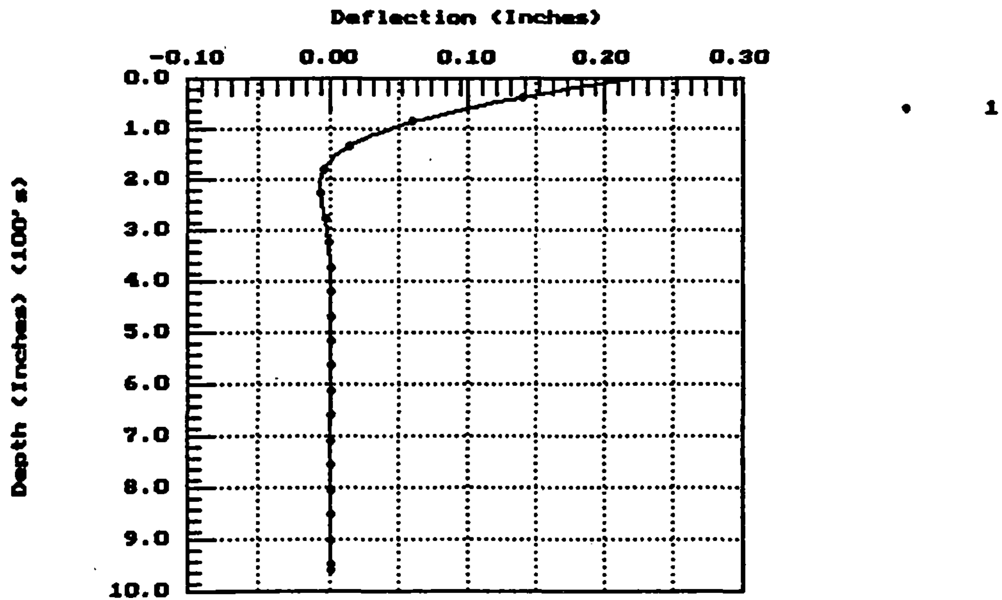
PILE-HEAD DEFLECTION = .219D+00 IN
COMPUTED SLOPE AT PILE HEAD = .218D-02
MAXIMUM BENDING MOMENT = .466D+06 LBS-IN
MAXIMUM SHEAR FORCE = .900D+04 LBS
NO. OF ITERATIONS = 4
NO. OF ZERO DEFLECTION POINTS = 5

S U M M A R Y   T A B L E

****

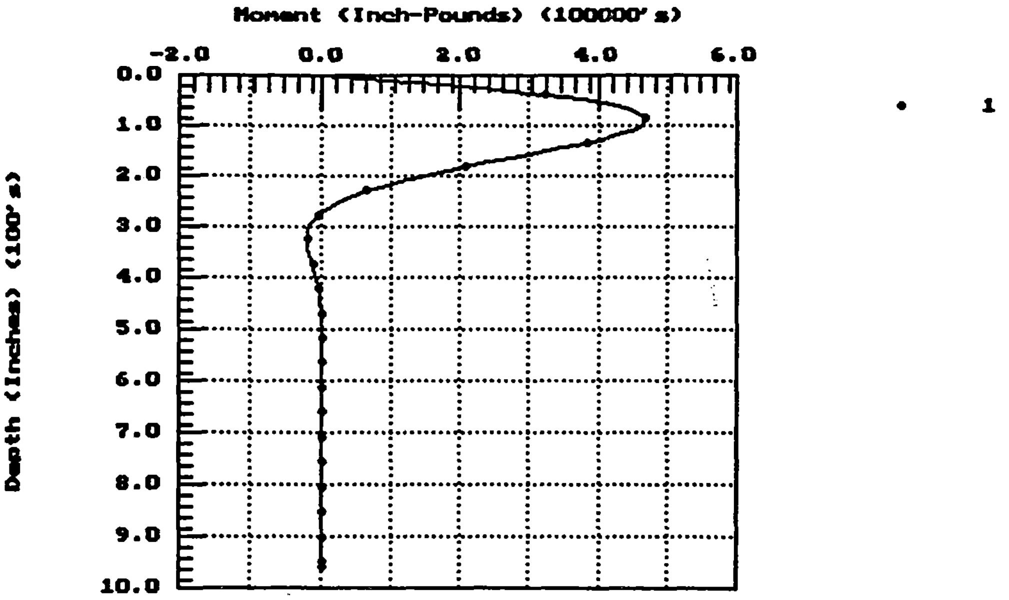
BOUNDARY CONDITION BC1	BOUNDARY CONDITION BC2	AXIAL LOAD LBS	PILE HEAD DEFLECTION IN	MAX. MOMENT IN-LBS	MAX. SHEAR LBS
.9000D+04	.0000D+00	.1659D+06	.2187D+00	.4659D+06	.9000D+04

1A



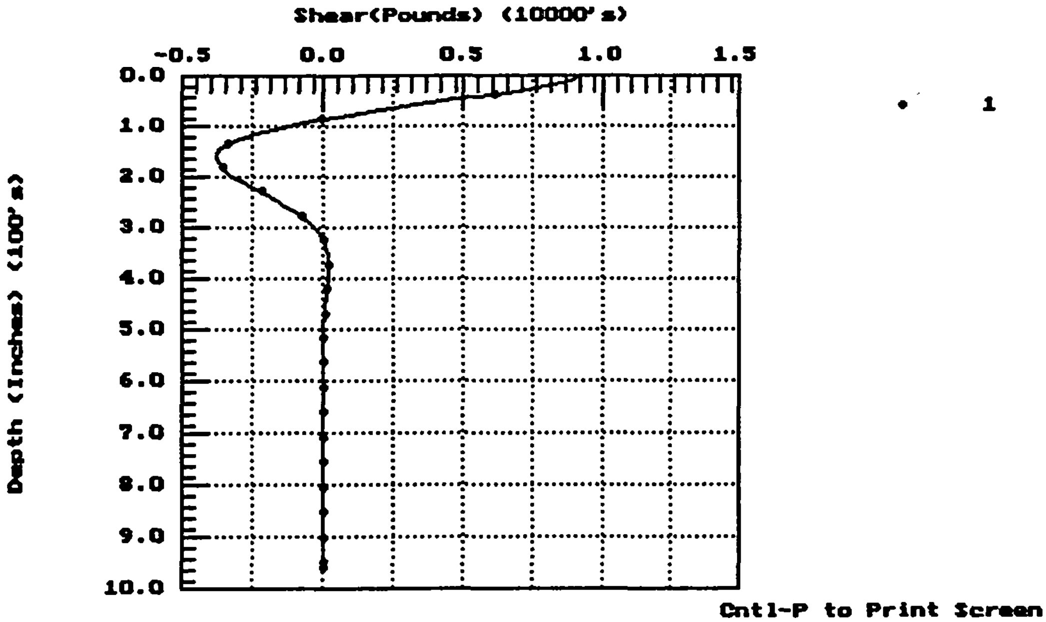
Cntl-P to Print Screen

1A

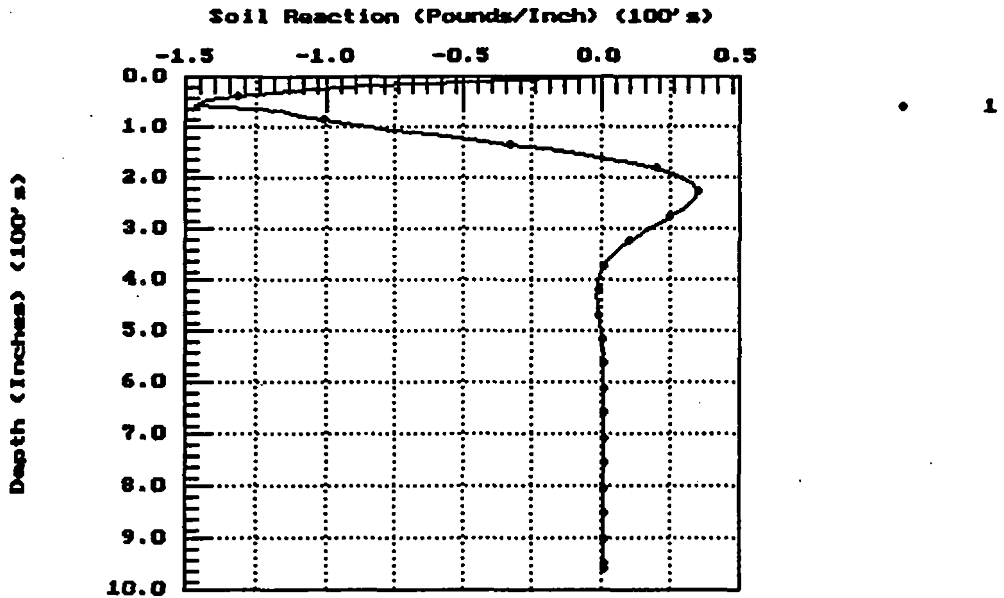


Cntl-P to Print Screen

1A


Shear(Pounds) (10000's)
-0.5
0.0
0.5
1.0
1.5
Depth (Inches) (100's)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
1
Cntl-P to Print Screen

1A



Cntl-P to Print Screen

DOUBLE ALUMINUM BOX BEAM
30 FT SPAN, 17 FT HEIGHT
2X2 DRILLED SHAFT GROUP

COMPRESSIVE LOAD
(D+L+B)(.75) = 126.75 KIPS/DRILLED SHAFT = 63.375 TON/DRILLED SHAFT

TENSION LOAD
(D+L+B) = 115.4 KIPS/DRILLED SHAFT = 57.7 TONS/DRILLED SHAFT

LATERAL LOAD
DUE TO BRAKING Fz = 9 KIPS/DRILLED SHAFT

TO ACHIEVE A AXIAL COMPRESSIVE LOAD OF 126.75 KIPS/SHAFT (63.38 TONS/PILE), A 36" DIAMETER DRILLED SHAFT, 35 FT LONG IS NEEDED. THIS SHAFT SIZE WILL ALSO ACHIEVE THE TENSILE LOAD ON THE SHAFT (115.4 KIPS/SHAFT = 57.7 TONS/SHAFT).

THE ALLOWABLE CAPACITY (AXIAL) OF THE DRILLED SHAFT IS 75.2 TONS. THE ULTIMATE SIDE FRICTION IS 171 TONS WHICH EQUATES TO AN ALLOWABLE UPLIFT CAPACITY (SIDE FRICTION) OF 85.5 TONS WITH A SAFETY FACTOR OF 2.

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PROGRAM LPILE Version 3.0

MAGLEV ALUM BOX BEAM DOUBLE HT 17' SPAN 30', 36" 35' DRILLED SHAFT

UNITS--ENGLISH UNITS

I N P U T   I N F O R M A T I O N
****

THE LOADING IS STATIC

PILE GEOMETRY AND PROPERTIES

PILE LENGTH = 420.00 IN

2 POINTS

X	DIAMETER	MOMENT OF INERTIA	AREA	MODULUS OF ELASTICITY
IN	IN	IN**4	IN**2	LBS/IN**2
.00	36.000	.824D+05	.102D+04	.470D+07
420.00	36.000	.824D+05	.102D+04	.470D+07

SOILS INFORMATION

X AT THE GROUND SURFACE = .00 IN

2 LAYER(S) OF SOIL

LAYER 1
THE SOIL IS A SAND
X AT THE TOP OF THE LAYER = .00 IN
X AT THE BOTTOM OF THE LAYER = 60.00 IN
MODULUS OF SUBGRADE REACTION = .250D+02 LBS/IN**3

LAYER 2
THE SOIL IS A SAND
X AT THE TOP OF THE LAYER = 60.00 IN
X AT THE BOTTOM OF THE LAYER = 420.00 IN
MODULUS OF SUBGRADE REACTION = .200D+02 LBS/IN**3

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH

4 POINTS

X,IN WEIGHT,LBS/IN**3

.00	.58D-01
60.00	.58D-01
60.00	.22D-01
420.00	.22D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH

2 POINTS

X,IN	C,LBS/IN**2	PHI,DEGREES	E50
.00	.000D+00	.290D+02	-----
420.00	.000D+00	.290D+02	-----

BOUNDARY AND LOADING CONDITIONS

LOADING NUMBER 1

BOUNDARY-CONDITION CODE = 1
LATERAL LOAD AT THE PILE HEAD = .900D+04 LBS
MOMENT AT THE PILE HEAD = .000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD = .127D+06 LBS

FINITE-DIFFERENCE PARAMETERS
NUMBER OF PILE INCREMENTS = 100
DEFLECTION TOLERANCE ON DETERMINATION OF CLOSURE = .100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS = 100
MAXIMUM ALLOWABLE DEFLECTION = .36D+03 IN

OUTPUT CODES
KOUTPT = 1
KPYOP = 0
INC = 4

O U T P U T   I N F O R M A T I O N

****

LOADING NUMBER 1

BOUNDARY CONDITION CODE	=	1
LATERAL LOAD AT THE PILE HEAD	=	.900D+04 LBS
MOMENT AT THE PILE HEAD	=	.000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD	=	.127D+06 LBS

X	DEFLECTION	MOMENT	SHEAR	SOIL REACTION	TOTAL STRESS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.826D-01	.610D-06	.900D+04	.000D+00	.125D+03	.388D+12
16.80	.746D-01	.151D+06	.873D+04	-.313D+02	.157D+03	.388D+12
33.60	.667D-01	.293D+06	.799D+04	-.560D+02	.188D+03	.388D+12
50.40	.590D-01	.419D+06	.688D+04	-.743D+02	.216D+03	.388D+12
67.20	.516D-01	.525D+06	.565D+04	-.655D+02	.239D+03	.388D+12
84.00	.446D-01	.611D+06	.450D+04	-.716D+02	.258D+03	.388D+12
100.80	.380D-01	.677D+06	.327D+04	-.738D+02	.272D+03	.388D+12
117.60	.319D-01	.723D+06	.203D+04	-.728D+02	.282D+03	.388D+12
134.40	.264D-01	.747D+06	.840D+03	-.690D+02	.288D+03	.388D+12
151.20	.214D-01	.753D+06	-.272D+03	-.631D+02	.289D+03	.388D+12
168.00	.169D-01	.740D+06	-.127D+04	-.556D+02	.286D+03	.388D+12
184.80	.130D-01	.712D+06	-.214D+04	-.471D+02	.280D+03	.388D+12
201.60	.960D-02	.670D+06	-.285D+04	-.380D+02	.271D+03	.388D+12
218.40	.668D-02	.618D+06	-.341D+04	-.287D+02	.259D+03	.388D+12
235.20	.422D-02	.557D+06	-.382D+04	-.195D+02	.246D+03	.388D+12
252.00	.215D-02	.491D+06	-.407D+04	-.107D+02	.232D+03	.388D+12
268.80	.446D-03	.421D+06	-.418D+04	-.237D+01	.217D+03	.388D+12
285.60	-.952D-03	.351D+06	-.415D+04	.537D+01	.201D+03	.388D+12

302.40	-.210D-02	.283D+06	-.400D+04	.125D+02	.186D+03	.388D+12
319.20	-.303D-02	.218D+06	-.373D+04	.191D+02	.172D+03	.388D+12
336.00	-.381D-02	.158D+06	-.336D+04	.253D+02	.159D+03	.388D+12
352.80	-.447D-02	.106D+06	-.289D+04	.312D+02	.148D+03	.388D+12
369.60	-.506D-02	.620D+05	-.231D+04	.370D+02	.138D+03	.388D+12
386.40	-.559D-02	.287D+05	-.164D+04	.428D+02	.131D+03	.388D+12
403.20	-.611D-02	.743D+04	-.873D+03	.488D+02	.126D+03	.388D+12
420.00	-.662D-02	.000D+00	.000D+00	.551D+02	.125D+03	.388D+12

OUTPUT VERIFICATION

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = -.716D-05 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = -.863D-06 LBS

OUTPUT SUMMARY

PILE-HEAD DEFLECTION = .826D-01 IN
COMPUTED SLOPE AT PILE HEAD = .478D-03
MAXIMUM BENDING MOMENT = .753D+06 LBS-IN
MAXIMUM SHEAR FORCE = .900D+04 LBS
NO. OF ITERATIONS = 3
NO. OF ZERO DEFLECTION POINTS = 1

S U M M A R Y T A B L E
****

BOUNDARY CONDITION BC1	BOUNDARY CONDITION BC2	AXIAL LOAD LBS	PILE HEAD DEFLECTION IN	MAX. MOMENT IN-LBS	MAX. SHEAR LBS
.9000D+04	.0000D+00	.1268D+06	.8263D-01	.7531D+06	.9000D+04

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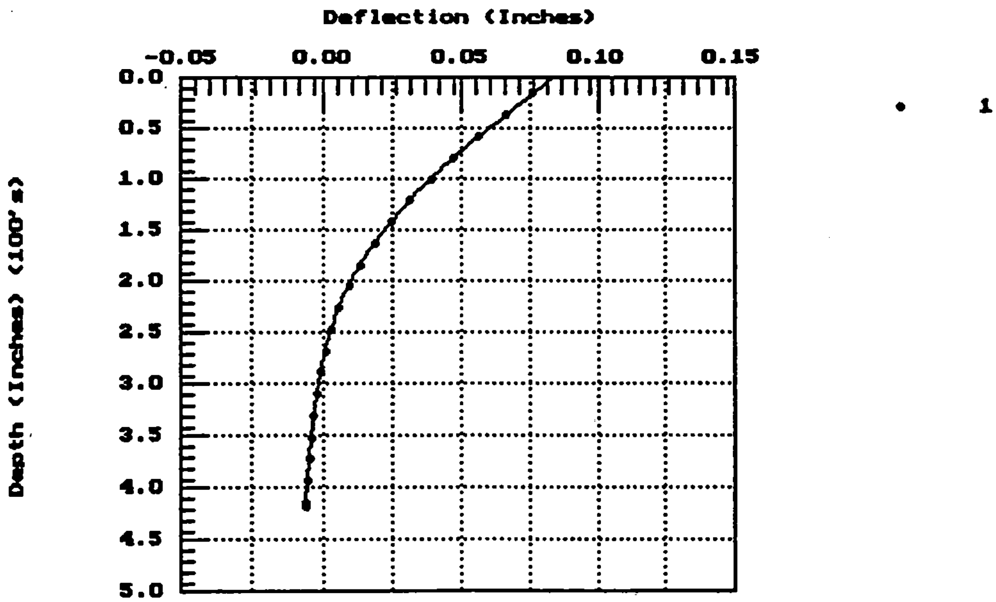
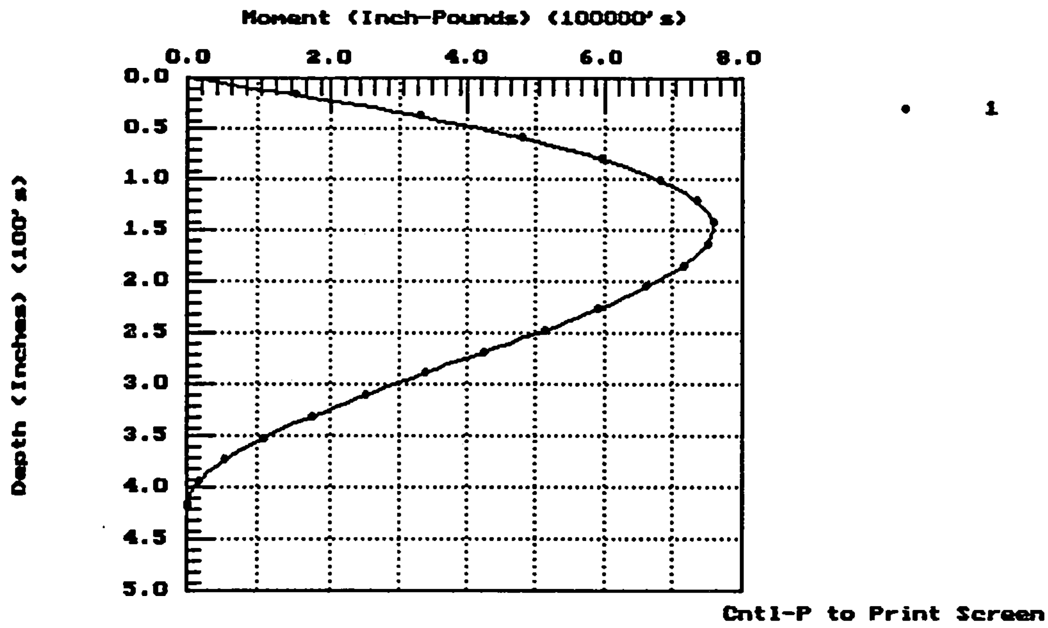
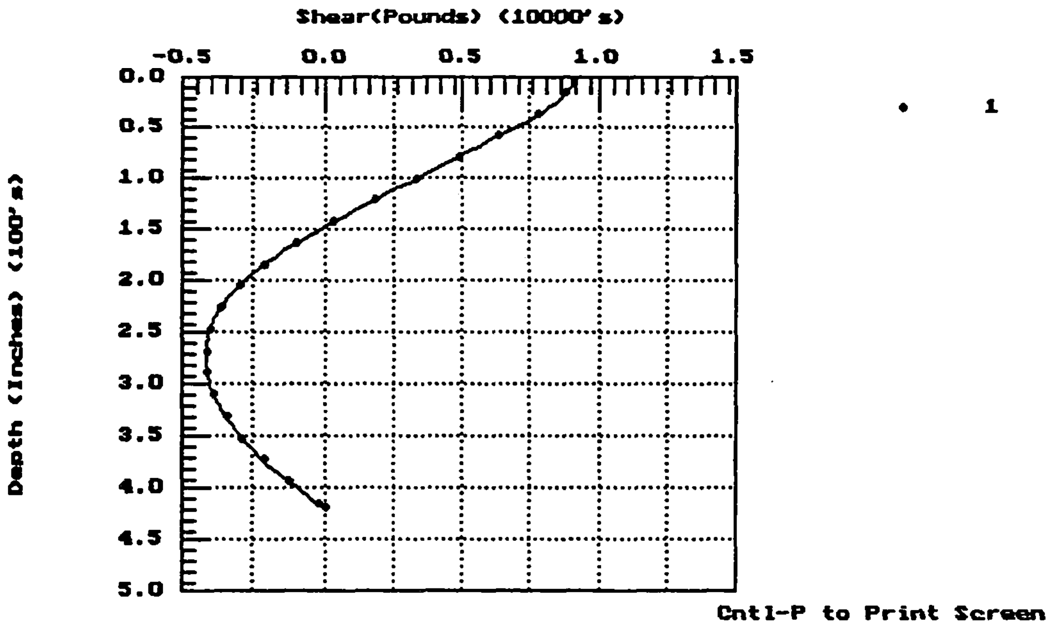


Cntl-P to Print Screen

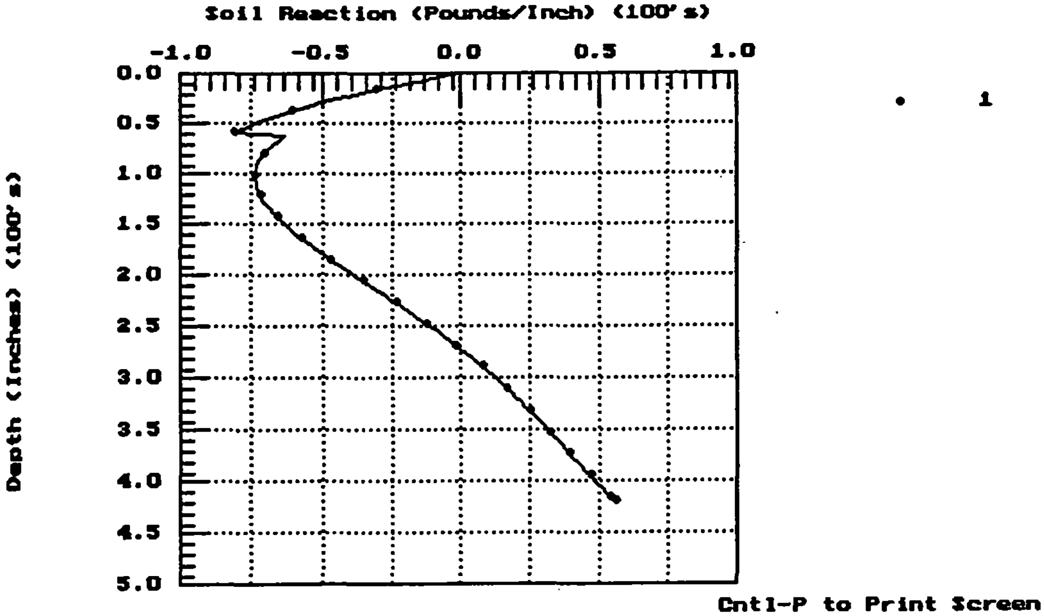
1A


Moment (Inch-Pounds) (100000's)
0.0
2.0
4.0
6.0
8.0
Depth (Inches) (100's)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
• 1
Cntl-P to Print Screen

1A


Shear(Pounds) (10000's)
-0.5
0.0
0.5
1.0
1.5
Depth (Inches) (100's)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
• 1
Cntl-P to Print Screen

1A



Soil Reaction (Pounds/Inch) (100's)
-1.0
-0.5
0.0
0.5
1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Depth (Inches) (100's)
• 1
Cntl-P to Print Screen

DOUBLE ALUMINUM BOX BEAM GUIDEWAY
45 FT SPAN, 30 FT HEIGHT
2X2 CONCRETE PILE GROUP

COMPRESSIVE LOAD
(D+L+B)(.75) = 165.9 KIPS/PILE = 82.95 TONS/PILE

TENSILE LOAD
(D+L+B)(.75) = 150 KIPS/PILE = 75.4 TONS/PILE

LATERAL LOAD
DUE TO BRAKING Fz = 9 KIPS/PILE

TO ACHIEVE A AXIAL COMPRESSIVE LOAD OF 82.95 TONS/PILE, A 18" SQUARE CONCRETE PILE, 65 FT LONG IS NEEDED. THIS PILE SIZE WILL ALSO ACHIEVE THE TENSILE LOAD 75.4 TONS/PILE.

THE ALLOWABLE CAPACITY OF THE PILE IS 86.54 TONS. THE ULTIMATE SIDE FRICTION IS 161.08 TONS WHICH EQUATES TO AN ALLOWABLE UPLIFT CAPACITY OF 80.54 TONS WITH A SAFETY FACTOR OF 2.

```
*******************************************************
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*   -----------------------------------------------   *
*                                                     *
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*******************************************************
```

PROGRAM LPILE Version 3.0

MAGLEV ALUM BOX BEAM DOUBLE HT 30' SPAN 45', 18" 65' PSC PILE

UNITS--ENGLISH UNITS

I N P U T   I N F O R M A T I O N
****

THE LOADING IS STATIC

PILE GEOMETRY AND PROPERTIES

PILE LENGTH = 780.00 IN

2 POINTS

X	DIAMETER	MOMENT OF INERTIA	AREA	MODULUS OF ELASTICITY
IN	IN	IN**4	IN**2	LBS/IN**2
.00	18.000	.875D+04	.324D+03	.470D+07
780.00	18.000	.875D+04	.324D+03	.470D+07

SOILS INFORMATION

X AT THE GROUND SURFACE = .00 IN

2 LAYER(S) OF SOIL

LAYER 1

THE SOIL IS A SAND

X AT THE TOP OF THE LAYER = .00 IN

X AT THE BOTTOM OF THE LAYER = 60.00 IN

MODULUS OF SUBGRADE REACTION = .250D+02 LBS/IN**3

LAYER 2

THE SOIL IS A SAND

X AT THE TOP OF THE LAYER = 60.00 IN

X AT THE BOTTOM OF THE LAYER = 780.00 IN

MODULUS OF SUBGRADE REACTION = .200D+02 LBS/IN**3

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH

4 POINTS

X,IN WEIGHT,LBS/IN**3

.00	.58D-01
60.00	.58D-01
60.00	.22D-01
780.00	.22D-01

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH

2 POINTS

X,IN	C,LBS/IN**2	PHI,DEGREES	E50
.00	.000D+00	.290D+02	-----
780.00	.000D+00	.290D+02	-----

BOUNDARY AND LOADING CONDITIONS

LOADING NUMBER 1

BOUNDARY-CONDITION CODE	=	1
LATERAL LOAD AT THE PILE HEAD	=	.900D+04 LBS
MOMENT AT THE PILE HEAD	=	.000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD	=	.166D+06 LBS

FINITE-DIFFERENCE PARAMETERS

NUMBER OF PILE INCREMENTS	=	100
DEFLECTION TOLERANCE ON DETERMINATION OF CLOSURE	=	.100D-04 IN
MAXIMUM NUMBER OF ITERATIONS ALLOWED FOR PILE ANALYSIS	=	100
MAXIMUM ALLOWABLE DEFLECTION	=	.18D+03 IN

OUTPUT CODES

KOUTPT = 1
KPYOP = 0
INC = 4

O U T P U T   I N F O R M A T I O N

****

LOADING NUMBER 1

BOUNDARY CONDITION CODE	=	1
LATERAL LOAD AT THE PILE HEAD	=	.900D+04 LBS
MOMENT AT THE PILE HEAD	=	.000D+00 IN-LBS
AXIAL LOAD AT THE PILE HEAD	=	.166D+06 LBS

X	DEFLECTION	MOMENT	SHEAR	SOIL REACTION	TOTAL STRESS	FLEXURAL RIGIDITY
IN	IN	LBS-IN	LBS	LBS/IN	LBS/IN**2	LBS-IN**2
*****	**********	**********	**********	**********	**********	**********
.00	.196D+00	-.113D-06	.900D+04	.000D+00	.512D+03	.411D+11
31.20	.140D+00	.270D+06	.709D+04	-.109D+03	.790D+03	.411D+11
62.40	.904D-01	.439D+06	.314D+04	-.109D+03	.964D+03	.411D+11
93.60	.510D-01	.492D+06	-.999D+02	-.935D+02	.102D+04	.411D+11
124.80	.230D-01	.453D+06	-.247D+04	-.566D+02	.978D+03	.411D+11
156.00	.567D-02	.357D+06	-.361D+04	-.175D+02	.879D+03	.411D+11
187.20	-.326D-02	.243D+06	-.366D+04	.121D+02	.762D+03	.411D+11
218.40	-.643D-02	.138D+06	-.300D+04	.279D+02	.654D+03	.411D+11
249.60	-.630D-02	.584D+05	-.206D+04	.312D+02	.572D+03	.411D+11
280.80	-.472D-02	.860D+04	-.115D+04	.264D+02	.521D+03	.411D+11
312.00	-.290D-02	-.158D+05	-.450D+03	.180D+02	.528D+03	.411D+11
343.20	-.142D-02	-.227D+05	-.222D+02	.968D+01	.535D+03	.411D+11
374.40	-.455D-03	-.199D+05	.176D+03	.339D+01	.532D+03	.411D+11
405.60	.430D-04	-.135D+05	.217D+03	-.347D+00	.526D+03	.411D+11
436.80	.221D-03	-.725D+04	.177D+03	-.192D+01	.519D+03	.411D+11
468.00	.224D-03	-.272D+04	.112D+03	-.209D+01	.515D+03	.411D+11
499.20	.159D-03	-.160D+03	.542D+02	-.158D+01	.512D+03	.411D+11
530.40	.867D-04	.877D+03	.154D+02	-.917D+00	.513D+03	.411D+11

561.60	.340D-04	.101D+04	-.440D+01	-.381D+00	.513D+03	.411D+11
592.80	.452D-05	.748D+03	-.107D+02	-.534D-01	.513D+03	.411D+11
624.00	-.741D-05	.419D+03	-.970D+01	.922D-01	.512D+03	.411D+11
655.20	-.926D-05	.169D+03	-.617D+01	.121D+00	.512D+03	.411D+11
686.40	-.688D-05	.325D+02	-.274D+01	.942D-01	.512D+03	.411D+11
717.60	-.357D-05	-.139D+02	-.458D+00	.511D-01	.512D+03	.411D+11
748.80	-.492D-06	-.105D+02	.450D+00	.736D-02	.512D+03	.411D+11
780.00	.235D-05	.000D+00	.000D+00	-.365D-01	.512D+03	.411D+11

OUTPUT VERIFICATION

THE MAXIMUM MOMENT IMBALANCE FOR ANY ELEMENT = .216D-06 IN-LBS
THE MAX. LATERAL FORCE IMBALANCE FOR ANY ELEMENT = -.131D-07 LBS

OUTPUT SUMMARY

PILE-HEAD DEFLECTION = .196D+00 IN
COMPUTED SLOPE AT PILE HEAD = .182D-02
MAXIMUM BENDING MOMENT = .492D+06 LBS-IN
MAXIMUM SHEAR FORCE = .900D+04 LBS
NO. OF ITERATIONS = 4
NO. OF ZERO DEFLECTION POINTS = 4

S U M M A R Y   T A B L E
****

BOUNDARY CONDITION BC1	BOUNDARY CONDITION BC2	AXIAL LOAD LBS	PILE HEAD DEFLECTION IN	MAX. MOMENT IN-LBS	MAX. SHEAR LBS
.9000D+04	.0000D+00	.1659D+06	.1958D+00	.4915D+06	.9000D+04

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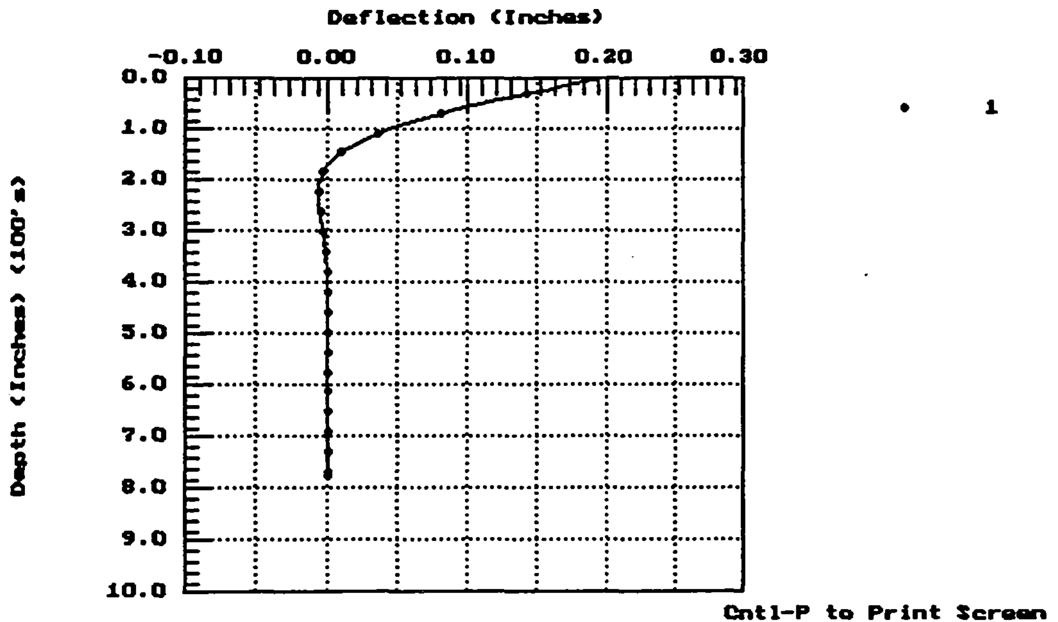
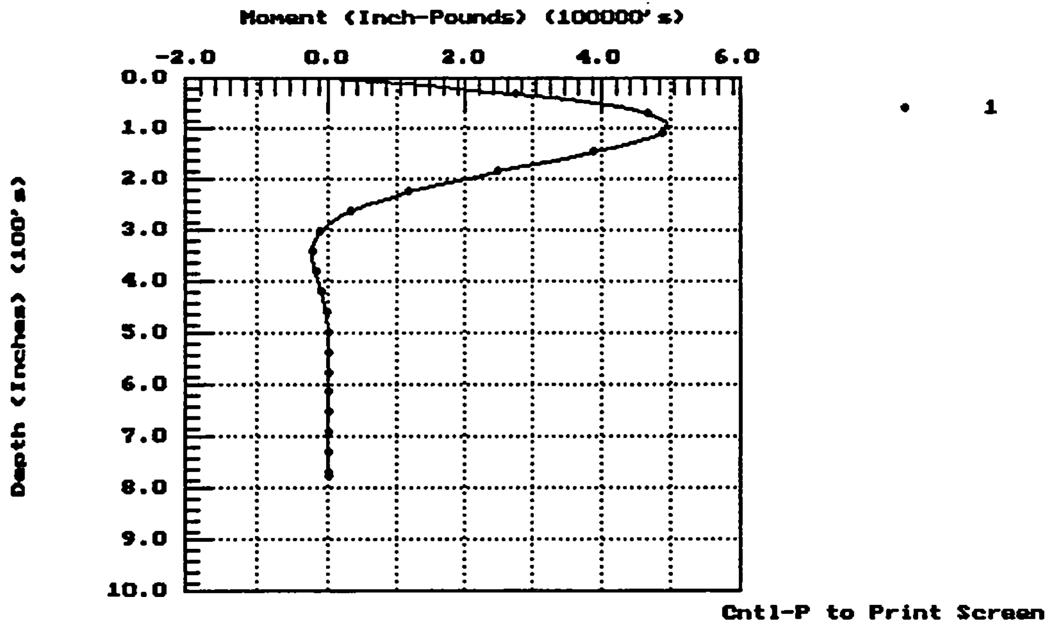
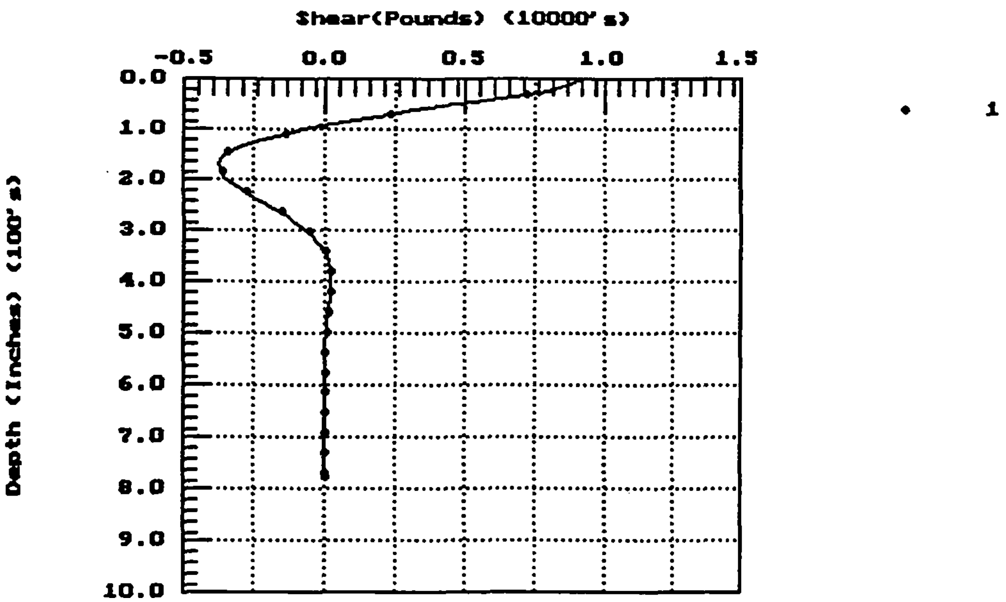

Deflection (Inches)
-0.10
0.00
0.10
0.20
0.30
Depth (Inches) (100's)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
1
Cntl-P to Print Screen

1A


Moment (Inch-Pounds) (100000's)
-2.0
0.0
2.0
4.0
6.0
Depth (Inches) (100's)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
1
Cntl-P to Print Screen

1A



Cntl-P to Print Screen

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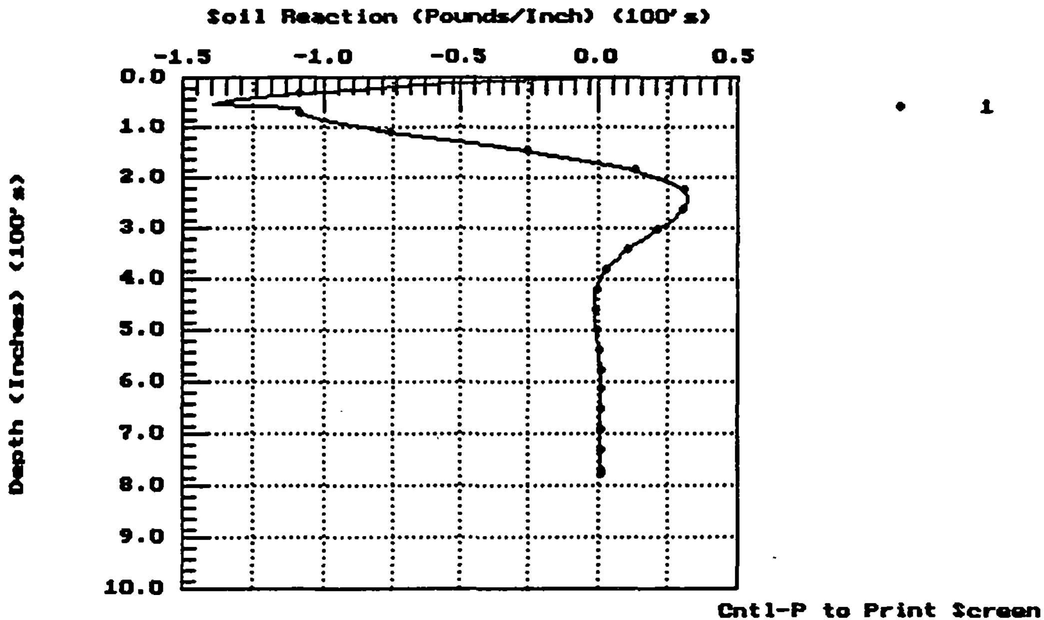


Soil Reaction (Pounds/Inch) (100's)
-1.5
-1.0
-0.5
0.0
0.5
Depth (Inches) (100's)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
• 1
Cntl-P to Print Screen

CALCULATION COVER SHEET

BCI JOB NUMBER 7901

CALCULATION NUMBER 4

CALCULATED BY LPM

DATE August 1992

JOB Magneplane - System Concept Design (SCD)

SUBJECT Axial Capacity of Drilled Shafts
Aluminum Box Beam - Double Guideway
30-Ft Span, 17 Ft. Height
36-inch Ø shaft, 35-Foot Length

REFERENCES FHWA "Drilled Shafts - Construction Procedures and Design Methods"
FHWA Drilled Shaft Design Spreadsheet
For Cohesionless Soils

REMARKS

BROMWELL & CARRIER, INC.

```
*****************************************************************
*                   UF GEOTECH GROUP - 4/27/88                  *
*              FHWA DRILLED SHAFT DESIGN SPREADSHEET            *
*  From Drilled Shafts:Construction Procedures and Design Methods *
*                       COHESIONLESS SOILS                      *
*****************************************************************
```

** INSTRUCTIONS & IMPORTANT INFORMATION **

{ALT} L MOVES ONE SCREEN LEFT
{ALT} R MOVES ONE SCREEN RIGHT
{ALT} D MOVES CURSOR TO THE DESIGN PROGRAM
{ALT} B MOVES THE CURSOR TO THE BORING LOG
{ALT} G SHOWS THE LOAD - SETTLEMENT CURVE FOR THE LOAD TEST

ALL VALUES MARKED BY "*" MUST BE INPUT BY HAND. ALL OTHER VALUES ARE AUTOMATICALLY CALCULATED.

THE BORING LOG CAN BE ACCESSED FROM THIS SCREEN BY PgDn.

BORING LOG
==========

* DEPTH (FT)	(DELTA) (DEPTH)	* SPT (BLOWS)	(DELTA) (SPT)
2	2.00	10	0.00
4	2.00	10	0.00
6	2.00	10	0.00
8	2.00	10	0.00
10	2.00	10	0.00
12	2.00	10	0.00
14	2.00	10	0.00
16	2.00	10	0.00
18	2.00	10	0.00
20	2.00	10	0.00
22	2.00	10	0.00
24	2.00	10	0.00
26	2.00	10	0.00
28	2.00	10	0.00
30	2.00	10	0.00
32	2.00	10	0.00
34	2.00	10	0.00
36	2.00	10	0.00
38	2.00	10	0.00
40	2.00	10	0.00

****
* DESIGN PROGRAM *
****

1) THE PROGRAM IS DIVIDED INTO SIX SCREENS THAT CAN BE ACCESSED BY PRESSING EITHER PgUp OR PgDn.

2) THE SOIL CAN BE DIVIDED INTO A MAXIMUM OF TEN LAYERS ALONG THE LENGTH OF THE PILE WITH ONE OF THE DIVISIONS LOCATED AT THE GROUNDWATER SURFACE. IF APPLICABLE.

3) THE PREDICTED SETTLEMENT OF THE PILE CAN BE FOUND BY CHANGING THE ASSUMED SETTLEMENT AND ITERATING UNTIL THE LOAD MOBILIZED UNDER THE ASSUMED SETTLEMENT IS EQUAL TO THE PREDICTED ULTIMATE LOAD.

4) VALUES MARKED BY * ARE TO BE INPUT. ALL OTHER VALUES ARE CALCULATED.

5) THE LOAD SETTLEMENT CURVE MAY BE FOUND BY INPUTING DIFFERENT VALUES OF OF SETTLEMENT IN THE SIXTH SCREEN AND PRESSING (ALT) 6.

INPUT

* DIAMETER OF SHAFT (IN) =	36.00
* LENGTH OF SHAFT (FT) =	35.00
* UNIT WEIGHT OF SOIL (PCF) =	115.00
BOUYANT UNIT WEIGHT (PCF) =	52.60
* DEPTH TO WATER TABLE (FT) =	5.00

SKIN FRICTION

LAYER #	* DEPTH (FEET)	LAYER THICKNESS (FEET)	GAMMA (PCF)	INCREMENTAL EFFECTIVE STRESS (PSF)	INCREMENTAL AVG. EFF. STRESS (PSF)
1	5.00	5.00	115.00	575.00	287.50
2	10.00	5.00	52.60	263.00	131.50
3	15.00	5.00	52.60	263.00	131.50
4	20.00	5.00	52.60	263.00	131.50
5	25.00	5.00	52.60	263.00	131.50
6	30.00	5.00	52.60	263.00	131.50
7	35.00	5.00	52.60	263.00	131.50
8		0.00	115.00	0.00	0.00
9		0.00	115.00	0.00	0.00
10		0.00	115.00	0.00	0.00

SKIN FRICTION

LAYER #	* DEPTH (FEET)	EFFECTIVE STRESS (PSF)	AVG. EFF. STRESS (PSF)	AREA (FT^2)	BETA	Qs (TONS)
1	5.00	575.00	287.50	47.12	1.20	8.13
2	10.00	838.00	706.50	47.12	1.13	18.82
3	15.00	1101.00	969.50	47.12	1.02	23.36
4	20.00	1364.00	1232.50	47.12	0.94	27.16
5	25.00	1627.00	1495.50	47.12	0.86	30.29
6	30.00	1890.00	1758.50	47.12	0.79	32.82
7	35.00	2153.00	2021.50	47.12	0.73	34.79
8		2153.00	2153.00	0.00	0.70	0.00
9		2153.00	2153.00	0.00	1.20	0.00
10		2153.00	2153.00	0.00	1.20	0.00

END BEARING

N VALUE AT BASE =	10.00
AREA OF BASE (FT^2) =	7.07
Qb (TONS) =	42.41

OUTPUT

Qs =	175.36 TONS
Qb =	42.41 TONS
Qu =	217.77 TONS

SETTLEMENT CALCULATION
====================

* ASSUMED SETTLEMENT = 0.45 IN

SET/DIAM (12%MAX) = 1.25 %

SKIN FRICTION = 171.06 TONS

END BEARING = 16.94 TONS

Qu @ THIS SETTLEMENT = 188.00 TONS

Qu FROM FHWA = 217.77 TONS

SETTLEMENT FOR FAILURE (5% DIAM) = 1.80 IN

PREDICTED ULTIMATE SETTLEMENT = 0.45 IN

LOAD SETTLEMENT CURVE CALCULATION

# SETTLEMENT	SET/DIAM	Qs	Qb	Qu
0.01	0.03	19	0	20
0.10	0.28	124	4	128
0.20	0.56	161	8	169
0.50	1.39	169	18	187
0.60	1.67	161	21	183
0.70	1.94	154	24	178
0.80	2.22	153	26	179
0.90	2.50	153	29	181
1.00	2.78	153	31	183
1.10	3.06	153	33	185
1.50	4.17	153	39	192
1.60	4.44	153	41	193

SUPPLEMENT B: BACKUP MATERIALS FOR COSTS

This section contains the detailed line items for the cost estimation on the preliminary system design.

See also section 5.3.11. (Life Cycle Cost Report), section 3.2.3.j. (Upgrade plan) and appendix H of the Hypothetical Route Report.

TABLE OF CONTENTS

Sheet

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS

SUMMARY

COST ELEMENTS WBS NO.	DESCRIPTION	AVERAGE COST PER MILE	AVERAGE COST PER KM	TOTAL COST 100 MI/160 KM
12	MAIN GUIDEWAY COSTS			
121	ELEVATED GUIDEWAY COSTS			
1211	GUIDEWAY COST CONTINGENCY 15%	$2,220,100	$1,379,500	$222,010,000
1213	DOUBLE ELEVATED GUIDEWAY COSTS	14,800,500	9,196,800	1,480,050,000
	TOTAL WBS NO. 121	17,020,600	10,576,300	1,702,060,000
15	SYSTEMWIDE ELECTRICAL AND COMMUNICATIONS COSTS			
151	SYSTEMWIDE ELECTRICAL CONTINGENCY			
	GUIDEWAY ELEC. (WBS 152) 15%	972,800	608,000	97,284,000
	COMM.& CONTROL SYS. (INCL. WITH WBS 153)			
	TOTAL WBS NO. 151	972,800	608,000	97,284,000
152	GUIDEWAY ELECTRIFICATION COSTS			
1521	OVERHEAD DISTRIBUTION LINE COSTS	150,000	93,800	15,000,000
1523	POWER SUBSTATION & CONVERTER STATION COSTS	1,363,100	851,900	136,309,000
1526	LSM WINDING COSTS	4,972,400	3,107,800	497,244,000
	TOTAL WBS NO. 152	6,485,500	4,053,500	648,553,000
153	COMMUNICATIONS AND CONTROL SYSTEM COSTS			
1531	- GLOBAL CONTROL FACILITY COSTS	13,400	8,400	1,343,000
1532	- GUIDEWAY COMMUNICATIONS COMMAND AND CONTROL SYSTEMS COSTS	477,600	298,500	47,760,000
	TOTAL WBS NO. 153	491,000	306,900	49,103,000
	TOTAL WBS NOS. 152 & 153	6,976,500	4,360,400	697,656,000
	TOTAL WBS NO. 15	7,949,300	4,968,400	794,940,000

MAGLEV COST ESTIMATION | SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS | SHEET 2

SUMMARY

COST ELEMENTS

WBS NO.	DESCRIPTION	AVERAGE COST PER MILE	AVERAGE COST PER KM	TOTAL COST 100 MI/160 KM
18	VEHICLE COSTS			
181	VEHICLE COST CONTINGENCY — INCL. WITH VEHICLE COST			
182	VEHICLE COST	4,044,200	2,527,600	404,420,000
	TOTAL WBS NO. 18	4,044,200	2,527,600	404,420,000
	TOTAL ESTIMATED CAPITAL COST	$29,014,100	$18,072,300	$2,901,420,000

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 3

CAPITAL COST ELEMENT: WBS NO. 1213 - DOUBLE ELEVATED GUIDEWAY COSTS

COST ELEMENTS DOUBLE ELEVATED GUIDEWAY - 30' SPAN X 17' HIGH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ALUMINUM GUIDE RAIL - DOUBLE ELEVATED GUIDEWAY				
FOOTING EXCAVATION	CY	8,184	$1.95	$15,964
FOOTING BACKFILL	CY	4,682	8.90	41,669
FOOTING CONCRETE	CY	3,502	134.74	471,868
CONCRETE COLUMNS	CY	1,109	728.80	808,241
CONCRETE CROSS BEAMS	CY	2,464	530.96	1,308,293
ALUMINUM GUIDE RAIL MATERIAL/FABRICATION	TN	1,342	8279.46	11,111,035
ALUMINUM GUIDE RAIL DELIVER/ERECTION	TN	1,342	240.55	322,813
ALUMINUM GUIDE RAIL ALIGNMENT	LF	10,560	1.50	15,800
MOBILIZATION/DEMOBILIZATION	LS	5%		704,784
				14,800,467
TOTAL ESTIMATED CONSTRUCTION COST PER MILE				USE $14,800,500 PER MILE
OR				
TOTAL ESTIMATED CONSTRUCTION COST PER KM				$9,196,800 PER KM

TOTAL ESTIMATED CONSTRUCTION COST FOR BASELINE ROUTE

ALUMINUM GUIDE RAIL - DOUBLE ELEVATED GUIDEWAY	MILE	100	$14,800,500	$1,480,050,000
TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS				$1,480,050,000

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 4

CAPITAL COST ELEMENT: WBS NO. 1521 - OVERHEAD DISTRIBUTION LINE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
34.5 KV OVERHEAD DISTRIBUTION LINE FROM SUBSTATION TO CONVERTER STATION ON 50 FT. STEEL POLES	MILE	100	$150,000	$15,000,000

TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS	$15,000,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE	$150,000 PER MILE
OR	
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE	$93,800 PER KM

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 5

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS

COST ELEMENTS WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. COST OF CONVERTER STATIONS (EVERY 5 MILES OR 8 KM)	EA	20	$6,686,000	$133,720,000
2. COST OF SUBSTATIONS (EVERY 33.3 MILES OR 53.3 KM)	EA	3	863,000	2,589,000
TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS				$136,309,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE				$1,363,100 PER MILE
OR				
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE				$851,900 PER KM

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 6

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS

COST ELEMENTS WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

1. CONVERTER STATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
CONCRETE BLOCK BUILDING ENCLOSURE	SF	5,500	$55.00	$303,000
EQUIPMENT COOLING SYSTEM	LS	1	293,000	293,000
34.5 KV SERVICE				
GANG OPERATED SWITCH	EA	2	10,300	20,600
GALVANIZED RIGID STEEL CONDUIT, 6"	LF	200	35.60	7,120
500 MCM, 34.5 KV CABLE, EPR	LF	600	10.10	6,060
CAPACITORS - EQUIPMENT	MVAR	9.6	3,340	32,060
CAPACITORS - INSTALLATION	MVAR	9.6	400	3,840
34.5 KV SWITCHGEAR - EQUIPMENT	CKT	9	50,000	450,000
34.5 KV SWITCHGEAR - INSTALLATION	CKT	9	520	4,680
CONVERTER CIRCUITS				
6 MVA TRANSFORMER - EQUIPMENT	EA	4	59,000	236,000
6 MVA TRANSFORMER - INSTALLATION	EA	4	1,040	4,160
6 MW CONVERTER - EQUIPMENT (INCL. INPUT TRANSF.)	EA	4	578,000	2,312,000
6 MW CONVERTER - INSTALLATION (INCL. INPUT TRANSF.)	EA	4	3,000	12,000
15 KV SWITCHGEAR - EQUIPMENT	CKT	4	25,000	100,000
15 KV SWITCHGEAR - INSTALLATION	CKT	4	520	2,080
GALVANIZED RIGID STEEL CONDUIT, 4"	LF	400	21.70	8,680
#1/0 AWG, 34.5 KV, EPR	LF	1,500	5.55	8,330
1200 A BUS DUCT, 5 KV	LF	100	2,000	200,000
GUIDEWAY WINDING SWITCH - EQUIPMENT	EA	4	15,000	60,000
GUIDEWAY WINDING SWITCH - INSTALLATION	EA	4	800	3,200
3-1/C 500 MCM, 15 KV TRIPLEX CABLE	LF	30,000	28.00	840,000
24" ALUMINUM LADDER CABLE TRAY	LF	15,000	15.80	237,000
CAPACITORS, SWITCHED - EQUIPMENT	MVAR	172.8	3,500	604,800
CAPACITORS, UNSWITCHED - EQUIPMENT	MVAR	172.8	4,000	691,200
CAPACITORS - INSTALLATION	MVAR	345.6	400	138,240
480 V SUBSTATION - EQUIPMENT	EA	1	60,000	60,000
480 V SUBSTATION - INSTALLATION	EA	1	4,680	4,680
BATTERY CHARGER	EA	1	5,000	5,000
UPS SYSTEM 5 KVA	EA	1	12,000	12,000
CABLE TRAY	LF	500	40.00	20,000
CONTROL CABLE	LF	2,100	3.00	6,300
TOTAL ESTIMATED CONSTRUCTION COST PER CONVERTER STATION				$6,686,000
THE AVERAGE COST PER MILE BASED ON SPACING OF A CONVERTER STATION EVERY 5 MILES (8 KM)				$1,337,200 PER MILE

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 7

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS

COST ELEMENTS WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

2. SUBSTATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
60 MVA TRANSFORMER, 115 KV-34.5 KV - EQUIPMENT	EA	1	$650,000	$650,000
60 MVA TRANSFORMER, 115 KV-34.5 KV - INSTALLATION	EA	1	30,000	30,000
115 KV CIRCUIT BREAKERS - EQUIPMENT	EA	1	70,000	70,000
115 KV CIRCUIT BREAKERS - INSTALLATION	EA	1	6,000	6,000
34.5 KV CIRCUIT BREAKERS - EQUIPMENT	EA	2	35,000	70,000
34.5 KV CIRCUIT BREAKERS - INSTALLATION	EA	2	3,000	6,000
115 KV AIR SWITCHES - EQUIPMENT	EA	2	6,600	13,200
115 KV AIR SWITCHES - INSTALLATION	EA	2	1,400	2,800
FOUNDATIONS, FENCING & MISC. ITEMS	LS	1	15,000	15,000

TOTAL ESTIMATED CONSTRUCTION COST PER SUBSTATION $863,000

THE AVERAGE COST PER MILE BASED ON SPACING OF A SUBSTATION EVERY 33.3 MILES (53.3 KM) $25,900 PER MILE

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 8

CAPITAL COST ELEMENT: WBS NO. 1526 - LSM WINDING COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
LSM WINDING COST PER 9 METER SECTION - 1.4 M WIDTH				
WIRE	M	325	$25.00	$8,125
FRP	M	9	90.00	810
EPOXY RESIN	LB	950	3.00	2,850
FACTORY LABOR	LS	1	2,000	2,000
TOTAL MATERIAL COST				$13,785
FIELD INSTALLATION COST	HR	5	40.00	200
TOTAL LSM WINDING COST PER 9 METER SECTION				$13,985 PER SECTION
AVERAGE COST PER METER - SINGLE GUIDEWAY				1553.89 PER SG. METER
AVERAGE COST PER METER - DOUBLE GUIDEWAY			X 2 =	3107.78 PER DG. METER
AVERAGE COST PER FT - SINGLE GUIDEWAY				473.60 PER SG. FT
AVERAGE COST PER FT - DOUBLE GUIDEWAY			X 2 =	947.20 PER DG. FT

TOTAL ESTIMATED CONSTRUCTION COST FOR BASELINE ROUTE

LSM WINDING COST FOR STRAIGHT SECTIONS FOR THE COMPLETE ROUTE	DG METER	160,000	3107.78	$497,244,000
TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS				$497,244,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE				$4,972,400 PER MILE
OR				
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE				$3,107,800 PER KM

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 9

CAPITAL COST ELEMENT: WBS NO. 1531 - GLOBAL CONTROL FACILITY COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
GLOBAL CONTROL CENTER EQUIPMENT UNIT				
CONTROL/SUPR. DISPLAY	EA	3	$90,800	$272,400
WORK STATION	EA	1	33,500	33,500
COMMUNICATION PROC. & CONTROLLER	EA	1	62,500	62,500
DATA PROCESSOR & CONTROL DISPLAY	EA	2	28,200	56,400
PRINTER	EA	2	1,300	2,600
HARD DISC & CONTROLLER	EA	3	3,500	10,500
TAPE & CONTROLLER	EA	2	11,000	22,000
FDDI				
GLOBAL-GLOBAL	EA	2	INCL. IN COMM. PROC.	
GLOBAL-WAYSIDE	EA	2	11,000	22,000
TELEPHONE EQUIPMENT	EA	1	INCL. IN COMM. PROC.	
RF COMMUNICATION	EA	1	56,000	56,000
POWER SUPPLY + UPS WITH BATTERIES	EA	2	18,000	36,000
SOFTWARE	SET	1	10,000	10,000
GPS SYSTEM	EA	1	28,000	28,000
GUIDEWAY CAMERA/MONITOR SYSTEM	SET	1	730,800	730,800
TOTAL GLOBAL CONTROL CENTER EQUIPMENT UNIT				$1,342,700

TOTAL ESTIMATED CONSTRUCTION COST FOR 100 MILES (160 KM) BASED ON 1 GLOBAL CONTROL CENTER EQUIPMENT UNIT SERVING 100 MILES (160 KM) OF SINGLE OR DOUBLE GUIDEWAY — USE $1,343,000 TOTAL

THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE — $13,400 PER MILE

OR

THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE — $8,400 PER KM

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 10

CAPITAL COST ELEMENT: WBS NO. 1532 - GUIDEWAY COMMUNICATIONS COMMAND AND CONTROL SYSTEMS COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. WAYSIDE CONTROL AND COMMUNICATION EQUIPMENT UNIT				
COMMUNICATION PROCESSOR & CONTROL	EA	3	$62,500	$187,500
FDDI			INCL. IN COMM. PROC.	
INTERFACE CONTINUOUS	EA	2	28,200	56,400
RF COMMUNICATION (REDUNDANT)	EA	2	56,000	112,000
POSITION MEASUREMENT - 1 PER 11 METERS	EA	728	2,500	1,820,000
POWER SUPPLY + UPS WITH BATTERIES (REDUNDANT)	EA	4	18,000	72,000
SOFTWARE	SET	3	10,000	30,000
ENCLOSURE & FANS	EA	1	10,000	10,000
SWITCH A/D I/F	EA	2	10,000	20,000
SWITCH I/F	EA	4	10,000	40,000
TOTAL WAYSIDE CONTROL AND COMMUNICATION EQUIPMENT UNIT				$2,347,900
2. TOTAL ESTIMATED CONSTRUCTION COST FOR BASELINE ROUTE				
WAYSIDE CONTROL AND COMMUNICATION EQUIPMENT UNIT	EA	20	$2,347,900	$46,958,000
FIBER OPTICS CABLE - PRIMARY	LF	528,000	0.76	401,000
FIBER OPTICS CABLE - REDUNDANT	LF	528,000	0.76	401,000
TOTAL ESTIMATED CONSTRUCTION COST FOR 100 MILES (160 KM) OF DOUBLE GUIDEWAY SYSTEM BASED ON EACH WAYSIDE SYSTEM SERVING 8 KM PER DOUBLE GUIDEWAY				$47,760,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE				$477,600 PER MILE
OR				
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE				$298,500 PER KM

TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS SHEET 11

CAPITAL COST ELEMENT: WBS NO. 182 - VEHICLE COST

WBS NO.- DESCRIPTION	LARGE VEHICLE (COMPOSITE VEHICLE) - 140 PASSENGERS	TOTAL
1821 - VEHICLE CARRIAGE, COACH BODY, WINDOWS, DOORS, COUPLERS, AND COWLING COSTS.		$12,143,000
AIRFRAME - MFG.	$9,484,000	
AIRFRAME - PURCHASED	$2,033,000	
SHIELDING - MFG.	$526,000	
SHIELDING - PURCHASED	$100,000	
1822 - INTERIOR FURNISHINGS, LIGHTING, HEATING, AIR CONDITIONING, DOOR OPERATING MECHANISM COSTS.		$1,850,000
INTERIOR - MFG.	$1,177,000	
HTG./COOL - MFG.	$473,000	
HTG./COOL - PURCHSED	$200,000	
1823 - LEVITATION AND GUIDANCE SYSTEM (INCLUDING SUSPENSION AND CONTROLS) COSTS.		$1,672,000
SUSPENSION - MFG.	$131,000	
MAGNETS - PURCHASED	$702,000	
CRYOGENICS - MFG.	$26,000	
CRYOGENICS - PURCHASED	$88,000	
GUIDANCE - MFG.	$210,000	
GUIDANCE - PURCHASED	$515,000	
1824 - ON-BOARD CONTROLS - RAYTHEON PURCHASE		$450,000
1825 - VEHICLE PROPULSION AND BRAKING SYSTEM COSTS		$2,149,000
GR/SKIDS - MFG.	$1,314,000	
MAGNETS - PURCHASED	$835,000	
1826 - ON BOARD POWER SUPPLY SYSTEM COSTS.		$759,000
COILS - MFG.	N/A	
COILS - PURCHASED	$200,000	
CONVERTER - MFG.	$59,000	
CONVERTER - PURCHASED	$300,000	
BATTERIES - PURCHASED	$50,000	
MECHANICAL HARDWARE - PURCHASED	$50,000	
ELECTRICAL HARDWARE - PURCHASED	$50,000	
WIRING - PURCHASED	$50,000	
MISCELLANEOUS COMPONENTS		$1,198,000
MISCELLANEOUS PARTS - MFG.	$1,098,000	
MISCELLANEOUS PARTS - PURCHASED	$100,000	
TOTAL ESTIMATED COST PER VEHICLE		$20,221,000 PER VEHICLE
X NUMBER OF VEHICLES	X	20
TOTAL ESTIMATED CAPITAL COST PER BASELINE PARAMETERS BASED ON 20 VEHICLES SERVING 100 MILES (160 KM) OF DOUBLE GUIDEWAY SYSTEM		$404,420,000 TOTAL
THE AVERAGE CAPITAL COST PER MILE OF THE BASELINE ROUTE		$4,044,200 PER MILE
OR		
THE AVERAGE CAPITAL COST PER KM OF THE BASELINE ROUTE		$2,527,600

BASELINE ROUTE - SEPTEMBER 1992

MAGLEV COST ESTIMATION | SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

SUMMARY | SHEET 1

COST ELEMENTS WBS NO.	DESCRIPTION	TOTAL $K 4,000 PPH	COST INCREASE 4 TO 8K PPH	TOTAL $K 8,000 PPH	COST INCREASE 8 TO 12K PPH	TOTAL $K 12,000 PPH	COST INCREASE 12 TO 25K	TOTAL $K 25,000 PPH
12	MAIN GUIDEWAY COSTS							
121	ELEVATED GUIDEWAY COSTS							
1211	GUIDEWAY COST CONTINGENCY (15%)	222,010	N/A	222,010	N/A	222,010	N/A	222,010
1213	DOUBLE ELEVATED GUIDEWAY COSTS	1,480,050	N/A	1,480,050	N/A	1,480,050	N/A	1,480,050
	TOTAL WBS NO. 121	1,702,060	N/A	1,702,060	N/A	1,702,060	N/A	1,702,060
15	SYSTEMWIDE ELECTRICAL AND COMMUNICATIONS COSTS							
151	SYSTEMWIDE ELECTRICAL CONTINGENCY							
	GUIDEWAY ELEC. (15% OF WBS 152)	97,284	387	97,671	13,748	111,420	777	112,196
	COMM.& CONTROL SYS. (W/WBS 153)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	TOTAL WBS NO. 151	97,284	387	97,671	13,748	111,420	777	112,196
152	GUIDEWAY ELECTRIFICATION COSTS							
1521	OVERHEAD DISTRIBUTION LINE COSTS	15,000	N/A	15,000	N/A	15,000	N/A	15,000
1523	POWER SUBSTATION & CONVERTER STATION COSTS	136,309	2,589	138,898	91,656	230,554	5,178	235,732
1526	LSM WINDING COSTS	497,244	N/A	497,244	N/A	497,244	N/A	497,244
	TOTAL WBS NO. 152	648,553	2,589	651,142	91,656	742,798	5,178	747,976
153	COMMUNICATIONS AND CONTROL SYSTEM COSTS							
1531	- GLOBAL CONTROL FACILITY COSTS	1,343	N/A	1,343	N/A	1,343	N/A	1,343
1532	- GUIDEWAY COMMUNICATIONS COMMAN AND CONTROL SYSTEMS COSTS	47,760	N/A	47,760	N/A	47,760	N/A	47,760
	TOTAL WBS NO. 153	49,103	N/A	49,103	N/A	49,103	N/A	49,103
	TOTAL WBS NOS. 152 & 153	697,656	2,589	700,245	91,656	791,901	5,178	797,079
	TOTAL WBS NO. 15	794,940	2,976	797,916	105,404	903,321	5,955	909,275

7

MAGLEV COST ESTIMATION SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

SUMMARY SHEET 2

COST ELEMENTS WBS NO.	DESCRIPTION	TOTAL $K 4,000 PPH	COST INCREASE 4 TO 8K PPH	TOTAL $K 8,000 PPH	COST INCREASE 8 TO 12K PPH	TOTAL $K 12,000 PPH	COST INCREASE 12 TO 25K	TOTAL $K 25,000 PPH
18	VEHICLE COSTS							
181	VEHICLE CONTINGENCY (W/WBS 182)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
182	VEHICLE COST	404,420	404,420	808,840	404,420	1,213,260	1,213,260	2,426,520
	TOTAL WBS NO. 18	404,420	404,420	808,840	404,420	1,213,260	1,213,260	2,426,520
	TOTAL ESTIMATED CAPITAL COST ($K)	2,901,420	407,396	3,308,816	509,824	3,818,641	1,219,215	5,037,855

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 3

COST ELEMENTS WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. COST OF CONVERTER STATIONS (EVERY 5 MILES OR 8 KM)	EA	20	$6,686,000	$133,720,000
2. COST OF SUBSTATIONS (EVERY 16.7 MILES OR 26.7 KM)	EA	6	863,000	5,178,000

TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS - 8,000 PPH	$138,898,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE - 8,000 PPH	$1,389,000 PER MILE
OR	
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE - 8,000 PPH	$868,100 PER KM

NOTE THE FOLLOWING LEVEL 4 LETTER DESIGNATIONS USED FOR WBS NO. 1523

WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 4

COST ELEMENTS WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

1. CONVERTER STATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
CONCRETE BLOCK BUILDING ENCLOSURE	SF	5,500	$55.00	$303,000
EQUIPMENT COOLING SYSTEM	LS	1	293,000	293,000
34.5 KV SERVICE				
GANG OPERATED SWITCH	EA	2	10,300	20,600
GALVANIZED RIGID STEEL CONDUIT, 6"	LF	200	35.60	7,120
500 MCM, 34.5 KV CABLE, EPR	LF	600	10.10	6,060
CAPACITORS - EQUIPMENT	MVAR	9.6	3,340	32,060
CAPACITORS - INSTALLATION	MVAR	9.6	400	3,840
34.5 KV SWITCHGEAR - EQUIPMENT	CKT	9	50,000	450,000
34.5 KV SWITCHGEAR - INSTALLATION	CKT	9	520	4,680
CONVERTER CIRCUITS				
6 MVA TRANSFORMER - EQUIPMENT	EA	4	59,000	236,000
6 MVA TRANSFORMER - INSTALLATION	EA	4	1,040	4,160
6 MW CONVERTER - EQUIPMENT (INCL. INPUT TRANSF.)	EA	4	578,000	2,312,000
6 MW CONVERTER - INSTALLATION (INCL. INPUT TRANSF.)	EA	4	3,000	12,000
15 KV SWITCHGEAR - EQUIPMENT	CKT	4	25,000	100,000
15 KV SWITCHGEAR - INSTALLATION	CKT	4	520	2,080
GALVANIZED RIGID STEEL CONDUIT, 4"	LF	400	21.70	8,680
#1/0 AWG, 34.5 KV, EPR	LF	1,500	5.55	8,330
1200 A BUS DUCT, 5 KV	LF	100	2,000	200,000
GUIDEWAY WINDING SWITCH - EQUIPMENT	EA	4	15,000	60,000
GUIDEWAY WINDING SWITCH - INSTALLATION	EA	4	800	3,200
3-1/C 500 MCM, 15 KV TRIPLEX CABLE	LF	30,000	28.00	840,000
24" ALUMINUM LADDER CABLE TRAY	LF	15,000	15.80	237,000
CAPACITORS, SWITCHED - EQUIPMENT	MVAR	172.8	3,500	604,800
CAPACITORS, UNSWITCHED - EQUIPMENT	MVAR	172.8	4,000	691,200
CAPACITORS - INSTALLATION	MVAR	345.6	400	138,240
480 V SUBSTATION - EQUIPMENT	EA	1	60,000	60,000
480 V SUBSTATION - INSTALLATION	EA	1	4,680	4,680
BATTERY CHARGER	EA	1	5,000	5,000
UPS SYSTEM 5 KVA	EA	1	12,000	12,000
CABLE TRAY	LF	500	40.00	20,000
CONTROL CABLE	LF	2,100	3.00	6,300

TOTAL ESTIMATED CONSTRUCTION COST PER CONVERTER STATION $6,686,000

THE AVERAGE COST PER MILE BASED ON SPACING OF A CONVERTER STATION EVERY 5 MILES (8 KM) $1,337,200 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 5

COST ELEMENTS WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

2. SUBSTATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
60 MVA TRANSFORMER, 115 KV-34.5 KV - EQUIPMENT	EA	1	$650,000	$650,000
60 MVA TRANSFORMER, 115 KV-34.5 KV - INSTALLATION	EA	1	30,000	30,000
115 KV CIRCUIT BREAKERS - EQUIPMENT	EA	1	70,000	70,000
115 KV CIRCUIT BREAKERS - INSTALLATION	EA	1	6,000	6,000
34.5 KV CIRCUIT BREAKERS - EQUIPMENT	EA	2	35,000	70,000
34.5 KV CIRCUIT BREAKERS - INSTALLATION	EA	2	3,000	6,000
115 KV AIR SWITCHES - EQUIPMENT	EA	2	6,600	13,200
115 KV AIR SWITCHES - INSTALLATION	EA	2	1,400	2,800
FOUNDATIONS, FENCING & MISC. ITEMS	LS	1	15,000	15,000

TOTAL ESTIMATED CONSTRUCTION COST PER SUBSTATION $863,000

THE AVERAGE COST PER MILE BASED ON SPACING OF A SUBSTATION EVERY 16.7 MILES (26.7 KM) $51,800 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 6

COST ELEMENTS WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. COST OF CONVERTER STATIONS (EVERY 5 MILES OR 8 KM)	EA	20	$11,268,800	$225,376,000
2. COST OF SUBSTATIONS (EVERY 16.7 MILES OR 26.7 KM)	EA	6	863,000	5,178,000

TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS - 12,000 PPH — $230,554,000 TOTAL

THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE - 12,000 PPH — $2,305,500 PER MILE

OR

THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE - 12,000 PPH — $1,441,000 PER KM

NOTE THE FOLLOWING LEVEL 4 LETTER DESIGNATIONS USED FOR WBS NO. 1523

WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

MAGLEV COST ESTIMATION — SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS — SHEET 7

COST ELEMENTS — WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

1. CONVERTER STATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
CONCRETE BLOCK BUILDING ENCLOSURE	SF	5,500	$55.00	$303,000
EQUIPMENT COOLING SYSTEM	LS	1	293,000	293,000
34.5 KV SERVICE				
GANG OPERATED SWITCH	EA	2	10,300	20,600
GALVANIZED RIGID STEEL CONDUIT, 6"	LF	200	35.60	7,120
500 MCM, 34.5 KV CABLE, EPR	LF	600	10.10	6,060
CAPACITORS - EQUIPMENT	MVAR	9.6	3,340	32,060
CAPACITORS - INSTALLATION	MVAR	9.6	400	3,840
34.5 KV SWITCHGEAR - EQUIPMENT	CKT	13	50,000	650,000
34.5 KV SWITCHGEAR - INSTALLATION	CKT	13	520	6,760
CONVERTER CIRCUITS				
6 MVA TRANSFORMER - EQUIPMENT	EA	8	59,000	472,000
6 MVA TRANSFORMER - INSTALLATION	EA	8	1,040	8,320
6 MW CONVERTER - EQUIPMENT (INCL. INPUT TRANSF.)	EA	8	578,000	4,624,000
6 MW CONVERTER - INSTALLATION (INCL. INPUT TRANSF.)	EA	8	3,000	24,000
15 KV SWITCHGEAR - EQUIPMENT	CKT	8	25,000	200,000
15 KV SWITCHGEAR - INSTALLATION	CKT	8	520	4,160
GALVANIZED RIGID STEEL CONDUIT, 4"	LF	800	21.70	17,360
#1/0 AWG, 34.5 KV, EPR	LF	3,000	5.55	16,650
1200 A BUS DUCT, 5 KV	LF	200	2,000	400,000
GUIDEWAY WINDING SWITCH - EQUIPMENT	EA	8	15,000	120,000
GUIDEWAY WINDING SWITCH - INSTALLATION	EA	8	800	6,400
3-1/C 500 MCM, 15 KV TRIPLEX CABLE	LF	30,000	28.00	840,000
24" ALUMINUM LADDER CABLE TRAY	LF	15,000	15.80	237,000
CAPACITORS, SWITCHED - EQUIPMENT	MVAR	345.6	3,500	1,209,600
CAPACITORS, UNSWITCHED - EQUIPMENT	MVAR	345.6	4,000	1,382,400
CAPACITORS - INSTALLATION	MVAR	691.2	400	276,480
480 V SUBSTATION - EQUIPMENT	EA	1	60,000	60,000
480 V SUBSTATION - INSTALLATION	EA	1	4,680	4,680
BATTERY CHARGER	EA	1	5,000	5,000
UPS SYSTEM 5 KVA	EA	1	12,000	12,000
CABLE TRAY	LF	500	40.00	20,000
CONTROL CABLE	LF	2,100	3.00	6,300

TOTAL ESTIMATED CONSTRUCTION COST PER CONVERTER STATION — $11,268,800

THE AVERAGE COST PER MILE BASED ON SPACING OF A CONVERTER STATION EVERY 5 MILES (8 KM) — $2,253,800 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 8

COST ELEMENTS WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

2. SUBSTATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
60 MVA TRANSFORMER, 115 KV-34.5 KV - EQUIPMENT	EA	1	$650,000	$650,000
60 MVA TRANSFORMER, 115 KV-34.5 KV - INSTALLATION	EA	1	30,000	30,000
115 KV CIRCUIT BREAKERS - EQUIPMENT	EA	1	70,000	70,000
115 KV CIRCUIT BREAKERS - INSTALLATION	EA	1	6,000	6,000
34.5 KV CIRCUIT BREAKERS - EQUIPMENT	EA	2	35,000	70,000
34.5 KV CIRCUIT BREAKERS - INSTALLATION	EA	2	3,000	6,000
115 KV AIR SWITCHES - EQUIPMENT	EA	2	6,600	13,200
115 KV AIR SWITCHES - INSTALLATION	EA	2	1,400	2,800
FOUNDATIONS, FENCING & MISC. ITEMS	LS	1	15,000	15,000

TOTAL ESTIMATED CONSTRUCTION COST PER SUBSTATION $863,000

THE AVERAGE COST PER MILE BASED ON SPACING OF A SUBSTATION EVERY 16.7 MILES (26.7 KM) $51,800 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 9

COST ELEMENTS WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. COST OF CONVERTER STATIONS (EVERY 5 MILES OR 8 KM)	EA	20	$11,268,800	$225,376,000
2. COST OF SUBSTATIONS (EVERY 8.3 MILES OR 13.3 KM)	EA	12	863,000	10,356,000

TOTAL ESTIMATED CONSTRUCTION COST PER THE BASELINE PARAMETERS - 25,000 PPH	$235,732,000 TOTAL
THE AVERAGE CONSTRUCTION COST PER MILE OF THE BASELINE ROUTE - 25,000 PPH	$2,357,300 PER MILE
OR	
THE AVERAGE CONSTRUCTION COST PER KM OF THE BASELINE ROUTE - 25,000 PPH	$1,473,300 PER KM

NOTE THE FOLLOWING LEVEL 4 LETTER DESIGNATIONS USED FOR WBS NO. 1523

WBS NO. 1523 A - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 4,000 PPH

WBS NO. 1523 B - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 8,000 PPH

WBS NO. 1523 C - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 12,000 PPH

WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 10.

COST ELEMENTS WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

1. CONVERTER STATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
CONCRETE BLOCK BUILDING ENCLOSURE	SF	5,500	$55.00	$303,000
EQUIPMENT COOLING SYSTEM	LS	1	293,000	293,000
34.5 KV SERVICE				
GANG OPERATED SWITCH	EA	2	10,300	20,600
GALVANIZED RIGID STEEL CONDUIT, 6"	LF	200	35.60	7,120
500 MCM, 34.5 KV CABLE, EPR	LF	600	10.10	6,060
CAPACITORS - EQUIPMENT	MVAR	9.6	3,340	32,060
CAPACITORS - INSTALLATION	MVAR	9.6	400	3,840
34.5 KV SWITCHGEAR - EQUIPMENT	CKT	13	50,000	650,000
34.5 KV SWITCHGEAR - INSTALLATION	CKT	13	520	6,760
CONVERTER CIRCUITS				
6 MVA TRANSFORMER - EQUIPMENT	EA	8	59,000	472,000
6 MVA TRANSFORMER - INSTALLATION	EA	8	1,040	8,320
6 MW CONVERTER - EQUIPMENT (INCL. INPUT TRANSF.)	EA	[illegible]	578,000	4,624,000
6 MW CONVERTER - INSTALLATION (INCL. INPUT TRANSF.)	EA	[illegible]	3,000	24,000
15 KV SWITCHGEAR - EQUIPMENT	CKT	8	25,000	200,000
15 KV SWITCHGEAR - INSTALLATION	CKT	8	520	4,160
[illegible]VANIZED RIGID STEEL CONDUIT, 4"	LF	800	21.70	17,360
#1/0 AWG, 34.5 KV, EPR	LF	3,000	5.55	16,650
1200 A BUS DUCT, 5 KV	LF	200	2,000	400,000
GUIDEWAY WINDING SWITCH - EQUIPMENT	EA	8	15,000	120,000
GUIDEWAY WINDING SWITCH - INSTALLATION	EA	8	800	6,400
3-1/C 500 MCM, 15 KV TRIPLEX CABLE	LF	30,000	28.00	840,000
24" ALUMINUM LADDER CABLE TRAY	LF	15,000	15.80	237,000
CAPACITORS, SWITCHED - EQUIPMENT	MVAR	345.6	3,500	1,209,600
CAPACITORS, UNSWITCHED - EQUIPMENT	MVAR	345.6	4,000	1,382,400
CAPACITORS - INSTALLATION	MVAR	691.2	400	276,480
480 V SUBSTATION - EQUIPMENT	EA	1	60,000	60,000
480 V SUBSTATION - INSTALLATION	EA	1	4,680	4,680
BATTERY CHARGER	EA	1	5,000	5,000
UPS SYSTEM 5 KVA	EA	1	12,000	12,000
CABLE TRAY	LF	500	40.00	20,000
CONTROL CABLE	LF	2,100	3.00	6,300
TOTAL ESTIMATED CONSTRUCTION COST PER CONVERTER STATION				$11,268,800
THE AVERAGE COST PER MILE BASED ON SPACING OF A CONVERTER STATION EVERY 5 MILES (8 KM)				$2,253,800 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 1523 - POWER SUBSTATION AND CONVERTER STATION COSTS SHEET 11

COST ELEMENTS WBS NO. 1523 D - POWER SUBSTATION AND CONVERTER STATION COSTS - THROUGHPUT OF 25,000 PPH

2. SUBSTATION

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
60 MVA TRANSFORMER, 115 KV-34.5 KV - EQUIPMENT	EA	1	$650,000	$650,000
60 MVA TRANSFORMER, 115 KV-34.5 KV - INSTALLATION	EA	1	30,000	30,000
115 KV CIRCUIT BREAKERS - EQUIPMENT	EA	1	70,000	70,000
115 KV CIRCUIT BREAKERS - INSTALLATION	EA	1	6,000	6,000
34.5 KV CIRCUIT BREAKERS - EQUIPMENT	EA	2	35,000	70,000
34.5 KV CIRCUIT BREAKERS - INSTALLATION	EA	2	3,000	6,000
115 KV AIR SWITCHES - EQUIPMENT	EA	2	6,600	13,200
115 KV AIR SWITCHES - INSTALLATION	EA	2	1,400	2,800
FOUNDATIONS, FENCING & MISC. ITEMS	LS	1	15,000	15,000

TOTAL ESTIMATED CONSTRUCTION COST PER SUBSTATION $863,000

THE AVERAGE COST PER MILE BASED ON SPACING OF A SUBSTATION EVERY 8.3 MILES (13.3 KM) $103,600 PER MILE

TOTAL ESTIMATED INCREMENTAL CAPITAL COST TO INCREASE CAPACITY 4,000 PPH TO 8,000 PPH TO 12,000 PPH TO 25,000 PPH

CAPITAL COST ELEMENT: WBS NO. 182 - VEHICLE COST SHEET 12

COST ELEMENTS — LARGE VEHICLE COST - 140 PASSENGERS (COMPOSITE VEHICLE)

1. VEHICLE COST PER VEHICLE

DESCRIPTION	TOTAL
1821 - VEHICLE CARRIAGE, COACH BODY, WINDOWS, DOORS, COUPLERS, AND COWLING COSTS	$12,143,000
1822 - INTERIOR FURNISHINGS, LIGHTING, HEATING, AIR CONDITIONING, DOOR OPERATING MECHANISM COSTS	1,850,000
1823 - LEVITATION AND GUIDANCE SYSTEM (INCLUDING SUSPENSION AND CONTROLS) COSTS	1,672,000
1824 - ON-BOARD CONTROLS	450,000
1825 - VEHICLE PROPULSION AND BRAKING SYSTEM COSTS	2,149,000
1826 - ON BOARD POWER SUPPLY SYSTEM COSTS	759,000
MISCELLANEOUS COMPONENTS	1,198,000
TOTAL ESTIMATED COST PER VEHICLE	$20,221,000

2. VEHICLE COST BY THROUGHPUT

THROUGHPUT	NUMBER OF VEHICLES	COST PER VEHICLE $K	TOTAL COST ALL VEHICLES $K	AVERAGE VEHICLE COST PER MILE (100 MILES)	AVERAGE VEHICLE COST PER KM (160 KM)
4,000	20	$20,221	$404,420	$4,044,200	$2,527,600
8,000	40	$20,221	$808,840	$8,088,400	$5,055,300
12,000	60	$20,221	$1,213,260	$12,132,600	$7,582,900
25,000	120	$20,221	$2,426,520	$24,265,200	$15,165,800

BASELINE ROUTE - SEPTEMBER 1992

MAGLEV COST ESTIMATION — SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS — SHEET 1

SUMMARY

COST ELEMENTS WBS NO.	DESCRIPTION	AVERAGE ANNUAL COSTS PER MILE	PER KM	TOTAL ANNUAL COSTS 100 MI/160 KM
21	MAINTENANCE COSTS			
211	GUIDEWAY MAINTENANCE COSTS	$50,000	$31,300	$5,000,000
212	VEHICLE MAINTENANCE COSTS	65,700	41,100	6,570,000
213	OTHER FIXED FACILITY MAINTENANCE COSTS			
2131	OVERHEAD DISTRIBUTION LINE COSTS	4,500	2,800	450,000
2132	POWER SUBSTATION & CONVERTER STATION COSTS	40,900	25,600	4,089,000
2136	LSM WINDING COSTS	53,800	33,600	5,376,000
2137	CENTRAL CONTROL FACILITY COSTS	1,800	1,100	178,000
2138	GUIDEWAY COMMUNICATIONS COMMAND AND CONTROL SYSTEMS COSTS	17,900	11,200	1,790,000
	TOTAL OTHER FIXED FACILITY MAINTENANCE COSTS	118,900	74,300	11,883,000
	TOTAL MAINTENANCE COSTS	234,600	146,700	23,453,000
22	ENERGY COSTS			
221	COST FOR VEHICLE ENERGY	646,500	404,100	64,653,000
222	COST FOR FIXED FACILITY ENERGY	2,100	1,300	210,000
	TOTAL ENERGY COSTS	648,600	405,400	64,863,000

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 2

SUMMARY

COST ELEMENTS

WBS NO.	DESCRIPTION	AVERAGE ANNUAL COSTS PER MILE	PER KM	TOTAL ANNUAL COSTS 100 MI/160 KM
23	ON-BOARD OPERATING COSTS			
231	ON-BOARD PERSONNEL COSTS	$55,200	$34,500	$5,520,000
	TOTAL ON-BOARD OPERATING COSTS	55,200	34,500	5,520,000
24	OTHER FIXED FACILITY OPERATING COSTS			
241	TRAFFIC CONTROL COSTS	9,600	6,000	964,000
	TOTAL OTHER FIXED FACILITY OPERATING COSTS	9,600	6,000	964,000
	TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS	$948,000	$592,600	$94,800,000

NOTE THE FOLLOWING:

1. THE WBS BREAKDOWN BASED ON INFORMATION IN THE CAPITAL COST ESTIMATION INTERIM REPORT, JANUARY 1992, PAGES 2-15 THROUGH 2-19.
2. ESTIMATE EXCLUDES RIGHT OF WAY COSTS.
3. ESTIMATE EXCLUDES GENERAL SALES AND ADMINISTRATIVE COSTS, INCLUDING SALES/MARKETING COSTS, INSURANCE COSTS AND ADMINISTRATION COSTS.

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 3

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 211 - GUIDEWAY MAINTENANCE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
LABOR TO MAINTAIN GUIDEWAY ANNUAL AVERAGE OF 4 MEN @ 200 FT/DAY (32 HR/200 FT = .16 HR/FT) DIRECT LABOR PER MILE = 5,280 FT X .16 = 845 HR ALLOW SUPERVISION LABOR @ 10% = 85 HR ALLOW MISC. SUPPORT LABOR @ 8% = 70 HR TOTAL LABOR PER MILE = 1,000 HR	HR	1,000	$30.00	$30,000
EQUIPMENT AND TOOLS PER LABOR HOUR TO MAINTAIN GUIDEWAY EQUIPMENT, TOOLS, VEHICLES, OPERATING EXPENSES, ETC. $10,000 COST PER MILE/1000 HRS. = $10.00/HR (5 WEEKS @ $2,000/WEEK = $10,000)	HR	1,000	$10.00	$10,000
MATERIAL COSTS ESTIMATE MATERIAL COST @ $10.00 PER HOUR OF LABOR	HR	1,000	$10.00	$10,000
TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER MILE	HR	1,000	$50.00	$50,000
X NUMBER OF MILES			X	100
TOTAL ESTIMATED ANNUAL GUIDEWAY MAINTENANCE COST PER THE BASELINE PARAMETERS				$5,000,000 TOTAL

THE AVERAGE ANNUAL GUIDEWAY MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS — $50,000 PER MILE

OR

THE AVERAGE ANNUAL GUIDEWAY MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS — $31,300 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS | SHEET 4

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 212 - VEHICLE MAINTENANCE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ORDINARY MAINTENANCE REQUIREMENTS ANNUAL AVERAGE COST PER VEHICLE BASED ON ONE HOUR OF MAINTENANCE PER HOUR OF OPERATIONS 18 HR/DAY X 365 DAYS/YR = 6,570 HR/YEAR PER VEHICLE (NOTE: $50.00/HR AVERAGE HOURLY RATE INCLUDES ALL LABOR, MATERIAL AND EQUIPMENT COSTS REQUIRED FOR ORDINARY MAINTENANCE)	HR	6,570	$50.00	$328,500

TOTAL ANNUAL AVERAGE MAINTENANCE COST PER VEHICLE BASED ON 6,570 OPERATING HOURS PER YEAR	$328,500 PER VEHICLE
X NUMBER OF VEHICLES	X 20
TOTAL ESTIMATED ANNUAL VEHICLE MAINTENANCE COST PER THE BASELINE PARAMETERS	$6,570,000 TOTAL
THE AVERAGE ANNUAL VEHICLE MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS	$65,700 PER MILE
OR	
THE AVERAGE ANNUAL VEHICLE MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS	$41,100 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 5

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2131 - OVERHEAD DISTRIBUTION LINE MAINTENANCE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ORDINARY MAINTENANCE REQUIREMENTS ANNUAL AVERAGE COST BASED ON HISTORICAL COST DATA FOR SIMILAR DISTRIBUTION PLANT FACILITIES AS A % OF CAPITAL COST:	LS	1	$450,000	450,000

CAPITAL COST ESTIMATE	$15,000,000 TOTAL
X % OF CAPITAL COST	3%
= MAINTENANCE ESTIMATE	$450,000 TOTAL

TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER THE BASELINE PARAMETERS — $450,000 TOTAL

THE AVERAGE ANNUAL MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS — $4,500 PER MILE

OR

THE AVERAGE ANNUAL MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS — $2,800 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 6

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2132 - POWER SUBSTATION & CONVERTER STATION MAINTENANCE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ORDINARY MAINTENANCE REQUIREMENTS ANNUAL AVERAGE COST BASED ON HISTORICAL COST DATA FOR SIMILAR DISTRIBUTION PLANT FACILITIES AS A % OF CAPITAL COST:	LS	1	$4,089,000	4,089,000

CAPITAL COST ESTIMATE	$136,309,000 TOTAL
X % OF CAPITAL COST	3%
= MAINTENANCE ESTIMATE	$4,089,000 TOTAL

TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER THE BASELINE PARAMETERS — $4,089,000 TOTAL

THE AVERAGE ANNUAL MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS — $40,900 PER MILE

OR

THE AVERAGE ANNUAL MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS — $25,600 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 7

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2136 - LSM WINDING MAINTENANCE COSTS

COST ELEMENTS	DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. PERIODIC TESTING AND REPAIRS					
LABOR COST PER LSM WINDING BLOCK IN THE SYSTEM PERIODIC TESTING = 192 HOURS (24 MAN DAYS/YEAR) PERIODIC REPAIR = 192 HOURS (24 MAN DAYS/YEAR) TOTAL = 384 HOURS (48 MAN DAYS/YEAR)		HR	384	$30.00	$11,520
AVERAGE COST OF EQUIPMENT, TOOLS, VEHICLES, OPERATING EXPENSES, ETC. PER LABOR HOUR ESTIMATE COST @ $10.00 PER HOUR OF LABOR		HR	384	$10.00	$3,840
MATERIAL COST TO MAKE MINOR REPAIRS TO THE LSM WINDING BLOCK AS REQUIRED AS PART OF THE PERIODIC TESTING & REPAIRS. ESTIMATE COST @ $10.00 PER HOUR OF LABOR		HR	384	$10.00	$3,840
TOTAL PERIODIC TESTING AND REPAIRS		HR	384	$50.00	$19,200
2. PERIODIC REPLACEMENT OF LSM WINDINGS					
ALLOW AVERAGE REPLACEMENT OF ONE LSM WINDING SECTION PER WINDING BLOCK PER YEAR					
LABOR COST PER LSM WINDING BLOCK TO REMOVE EXISTING SECTION AND INSTALL NEW SECTION		HR	16	$30.00	$480
AVERAGE COST OF EQUIPMENT, TOOLS, VEHICLES, OPERATING EXPENSES, ETC. PER LABOR HOUR		HR	16	$10.00	$160
MATERIAL COST OF NEW LSM WINDING SECTION AT LENGTH OF 8 METERS		EA	1	$13,790	$13,790
TOTAL PERIODIC REPLACEMENT OF LSM WINDINGS					$14,400
TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER LSM WINDING BLOCK					$33,600 PER BLOCK
X NUMBER OF LSM WINDING BLOCKS				X	160
TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER THE BASELINE PARAMETERS					$5,376,000 TOTAL
THE AVERAGE ANNUAL MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS					$53,800 PER MILE
OR					
THE AVERAGE ANNUAL MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS					$33,600 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 8

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2137 - CENTRAL CONTROL FACILITY MAINTENANCE COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ANNUAL AVERAGE MAINTENANCE COSTS				
GLOBAL CONTROL CENTER EQUIPMENT UNIT				
CAMERA/MONITOR	LS	1	$36,600	$36,600
FDDI	LS	1	1,000	1,000
WORKSTATION	LS	1	140,300	140,300

TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER THE BASELINE PARAMETERS	$178,000 TOTAL
THE AVERAGE ANNUAL MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS	$1,800 PER MILE
OR	
THE AVERAGE ANNUAL MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS	$1,100 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 9

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2138 - GUIDEWAY COMMUNICATIONS COMMAND & CONTROL SYSTEMS MAINT. COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ANNUAL AVERAGE MAINTENANCE COSTS				
WAYSIDE CONTROL AND COMMUNICATION EQUIPMENT UNITS				
CAMERA/MONITOR	LS	1	$36,600	$36,600
FDDI	LS	1	1,000	1,000
POSITION SENSOR	LS	1	91,000	91,000
TELEPHONE	LS	1	1,661,400	1,661,400

TOTAL ESTIMATED ANNUAL MAINTENANCE COST PER THE BASELINE PARAMETERS — $1,790,000 TOTAL

THE AVERAGE ANNUAL MAINTENANCE COST PER MILE OF THE BASELINE PARAMETERS — $17,900 PER MILE

OR

THE AVERAGE ANNUAL MAINTENANCE COST PER KM OF THE BASELINE PARAMETERS — $11,200 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 10

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 221 - COST FOR VEHICLE ENERGY

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
THE VEHICLE ENERGY REQUIRED FOR THE 100 STRAIGHT MILES OF THE BASELINE PARAMETERS IS 5,775 KW PER VEHICLE.	KWH	758,835,000	$0.0852	$64,652,740

20 VEHICLES X 5,775 KW = 115,500 KW PER HOUR

OPERATING HOURS = 18 X 365 = 6,570 HOURS PER YEAR

TOTAL ANNUAL ENERGY = 758,835,000 KWH PER YEAR

TOTAL ESTIMATED ANNUAL VEHICLE ENERGY COST PER THE BASELINE PARAMETERS	$64,652,740 USE $64,653,000 TOTAL
THE AVERAGE ANNUAL VEHICLE ENERGY COST PER MILE OF THE BASELINE PARAMETERS	$646,500 PER MILE
OR	
THE AVERAGE ANNUAL VEHICLE ENERGY COST PER KM OF THE BASELINE PARAMETERS	$404,100 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 11

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 222 - COST FOR FIXED FACILITY ENERGY

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
1. GLOBAL CONTROL CENTER FACILITY 840 SF X 20 W = 17 KW PER HOUR 24 X 365 = 8,760 HOURS PER YEAR TOTAL ANNUAL ENERGY = 147,168 KWH PER YEAR	KWH	147,168	$0.0852	$12,540
2. ENERGY FOR WAYSIDE CONTROL & COMMUN. EQUIP. UNITS 20 EA X 13 KW PER HR = 260 KW PER HOUR 24 X 365 = 8,760 HOURS PER YEAR TOTAL ANNUAL ENERGY = 2,277,600 KWH PER YEAR	KWH	2,277,600	$0.0852	$194,050
TOTAL ESTIMATED ANNUAL FIXED FACILITY ENERGY COST PER THE BASELINE PARAMETERS				$206,590 USE $210,000 TOTAL
THE AVERAGE ANNUAL FIXED FACILITY ENERGY COST PER MILE OF THE BASELINE PARAMETERS				$2,100 PER MILE
OR				
THE AVERAGE ANNUAL FIXED FACILITY ENERGY COST PER KM OF THE BASELINE PARAMETERS				$1,300 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS SHEET 12

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 231 - ON-BOARD PERSONNEL COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ON-BOARD PERSONNEL REQUIRMENTS	HR	175,200	$30.00	$5,256,000

BASED ON THE FOLLOWING CRITERIA:
AVERAGE TRIP LENGTH OF 3 HOURS
TOTAL OF 20 VEHICLES FOR 100 MILES
1 OPERATOR/ATTENDANT PER VEHICLE TRIP
3 LABOR SHIFTS AT 8 HOURS EACH

1 OPERATOR/ATTENDANT X 3 SHIFTS = 24 HOURS PER VEHICLE DAY
20 VEHICLES X 24 HOURS/DAY X 365 DAYS = 175,200

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
SUPERVISION & SUPPORT LABOR FOR ON-BOARD PERSONNEL	HR	8,760	$30.00	$262,800

ALLOW 5% OF ON BOARD PERSONNEL = 8,760

TOTAL ESTIMATED ANNUAL ON-BOARD PERSONNEL COST PER THE BASELINE PARAMETERS — $5,518,800 USE $5,520,000 TOTAL

THE AVERAGE ANNUAL ON-BOARD PERSONNEL COST PER MILE OF THE BASELINE PARAMETERS — $55,200 PER MILE

OR

THE AVERAGE ANNUAL ON-BOARD PERSONNEL COST PER KM OF THE BASELINE PARAMETERS — $34,500 PER KM

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE COST PER BASELINE PARAMETERS

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 241 - TRAFFIC CONTROL COSTS

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
TRAFFIC CONTROL CENTER OPERATIONS	HR	32,120	$30.00	$964,000

BASED ON THE FOLLOWING LABOR REQUIREMENTS:

1 OPERATIONS SUPV. PER SHIFT X 3 SHIFTS	24 HRS/DAY
2 CONTROLLERS PER SHIFT X 3 SHIFTS	48 HRS/DAY
1 MAINTENANCE SUPV. PER DAY	8 HRS/DAY
1 MAINTENANCE PERSON PER DAY	8 HRS/DAY
DAILY TOTAL	88 HRS/DAY
	X 365 DAYS/YR
ANNUAL TOTAL	32,120 HRS/YEAR

TOTAL ESTIMATED ANNUAL OPERATING COST PER THE BASELINE PARAMETERS — $964,000 TOTAL

THE AVERAGE ANNUAL OPERATING COST PER MILE OF THE BASELINE PARAMETERS — $9,600 PER MILE

OR

THE AVERAGE ANNUAL OPERATING COST PER KM OF THE BASELINE PARAMETERS — $6,000 PER KM

BASELINE ROUTE - SEPTEMBER 1992

MAGLEV COST ESTIMATION

SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

SUMMARY

SHEET 1

COST ELEMENTS WBS NO.	DESCRIPTION	TOTAL $ 4,000 PPH	COST INCREASE 4K TO 8K	TOTAL $ 8,000 PPH	COST INCREASE 8K TO 12K	TOTAL $ 12,000 PPH	COST INCREASE 12K TO 25K	TOTAL $ 25,000 PPH
21	MAINTENANCE COSTS							
211	GUIDEWAY MAINTENANCE COSTS	$5,000,000	N/A	$5,000,000	N/A	$5,000,000	N/A	$5,000,000
212	VEHICLE MAINTENANCE COSTS	6,570,000	6,570,000	13,140,000	6,570,000	19,710,000	19,710,000	39,420,000
213	OTHER FIXED FACILITY MAINTENANCE COSTS							
2131	OVERHEAD DISTRIBUTION LINE COSTS	450,000	N/A	450,000	N/A	450,000	N/A	450,000
2132	POWER SUBSTATION & CONVERTER STATION COSTS	4,089,000	78,000	4,167,000	2,750,000	6,917,000	155,000	7,072,000
2136	LSM WINDING COSTS	5,376,000	N/A	5,376,000	N/A	5,376,000	N/A	5,376,000
2137	CENTRAL CONTROL FACILITY COSTS	178,000	N/A	178,000	N/A	178,000	N/A	178,000
2138	GUIDEWAY COMMUNICATIONS COMMAND AND CONTROL SYSTEMS COSTS	1,790,000	N/A	1,790,000	N/A	1,790,000	N/A	1,790,000
	TOTAL OTHER FACIL. MAINT. COSTS	11,883,000	78,000	11,961,000	2,750,000	14,711,000	155,000	14,866,000
	TOTAL MAINTENANCE COSTS	23,453,000	6,648,000	30,101,000	9,320,000	39,421,000	19,865,000	59,286,000
22	ENERGY COSTS							
221	COST FOR VEHICLE ENERGY	64,653,000	64,653,000	129,306,000	64,652,000	193,958,000	193,959,000	387,917,000
222	COST FOR FIXED FACILITY ENERGY	210,000	N/A	210,000	N/A	210,000	N/A	210,000
	TOTAL ENERGY COSTS	64,863,000	64,653,000	129,516,000	64,652,000	194,168,000	193,959,000	388,127,000

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

SUMMARY OF ANNUAL OPERATING AND MAINTENANCE COSTS SHEET 2

COST ELEMENTS WBS NO.	DESCRIPTION	TOTAL $ 4,000 PPH	COST INCREASE 4K TO 8K	TOTAL $ 8,000 PPH	COST INCREASE 8K TO 12K	TOTAL $ 12,000 PPH	COST INCREASE 12K TO 25K	TOTAL $ 25,000 PPH
23	ON-BOARD OPERATING COSTS							
231	ON-BOARD PERSONNEL COSTS	5,520,000	5,520,000	11,040,000	5,520,000	16,560,000	16,560,000	33,120,000
	TOTAL ON-BOARD OPERATING COSTS	5,520,000	5,520,000	11,040,000	5,520,000	16,560,000	16,560,000	33,120,000
24	OTHER FIXED FACILITY OPERATING COSTS							
241	TRAFFIC CONTROL COSTS	964,000	N/A	964,000	N/A	964,000	N/A	964,000
	TOTAL OTHER FACILITY OPER. COSTS	964,000	N/A	964,000	N/A	964,000	N/A	964,000
	TOTAL ANNUAL OPERATING AND MAINTENANCE COSTS	94,800,000	76,821,000	171,621,000	79,492,000	251,113,000	230,384,000	481,497,000

NOTE THE FOLLOWING:

1. THE WBS BREAKDOWN BASED ON INFORMATION IN THE CAPITAL COST ESTIMATION INTERIM REPORT, JANUARY 1992, PAGES 2-15 THROUGH 2-19.
2. ESTIMATE EXCLUDES RIGHT OF WAY COSTS.
3. ESTIMATE EXCLUDES GENERAL SALES AND ADMINISTRATIVE COSTS, INCLUDING SALES/MARKETING COSTS, INSURANCE COSTS AND ADMINISTRATION COSTS.

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 212 - VEHICLE MAINTENANCE COSTS SHEET 3

COST ELEMENTS

1. VEHICLE MAINTENANCE COSTS PER VEHICLE

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ORDINARY MAINTENANCE REQUIREMENTS ANNUAL AVERAGE COST PER VEHICLE BASED ON ONE HOUR OF MAINTENANCE PER HOUR OF OPERATIONS 18 HR/DAY X 365 DAYS/YR = 6,570 HR/YEAR PER VEHICLE	HR	6,570	$50.00	$328,500
(NOTE: $50.00/HR AVERAGE HOURLY RATE INCLUDES ALL LABOR, MATERIAL AND EQUIPMENT COSTS REQUIRED FOR ORDINARY MAINTENANCE)				
TOTAL ANNUAL MAINTENANCE COST PER VEHICLE BASED ON 6,570 OPERATING HOURS PER YEAR				$328,500

2. VEHICLE MAINTENANCE COSTS BY THROUGHPUT

THROUGHPUT	NUMBER OF VEHICLES	ANNUAL COST PER VEHICLE	ANNUAL COST ALL VEHICLES	AVERAGE ANNUAL MAINTENANCE COST COST PER MILE (100 MILES)	COST PER KM (160 KM)
4,000	20	$328,500	$6,570,000	$65,700	$41,100
8,000	40	$328,500	$ 13,140,000	$131,400	$82,100
12,000	60	$328,500	$ 19,710,000	$197,100	$123,200
25,000	120	$328,500	$ 39,420,000	$394,200	$246,400

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 2132 - POWER SUBSTATION & CONVERTER STATION MAINTENANCE COSTS SHEET 4

COST ELEMENTS

1. ESTIMATE BASIS FOR POWER SUBSTATION & CONVERTER STATION MAINTENANCE COSTS (USING THROUGHPUT OF 4,000 AS AN EXAMPLE)

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ORDINARY MAINTENANCE REQUIREMENTS	LS	1	$4,089,000	$4,089,000

ANNUAL AVERAGE COST BASED ON HISTORICAL COST DATA FOR SIMILAR DISTRIBUTION PLANT FACILITIES AS A % OF CAPITAL COST:

CAPITAL COST ESTIMATE	$136,309,000 TOTAL
X % OF CAPITAL COST	3%
= MAINTENANCE ESTIMATE	$4,089,000 TOTAL

TOTAL ESTIMATED ANNUAL MAINTENANCE COST BASED ON THROUGHPUT OF 4,000 $4,089,000

2. ESTIMATE OF POWER SUBSTATION & CONVERTER STATION MAINTENANCE COSTS BY THROUGHPUTS

THROUGHPUT	CAPITAL COST ESTIMATE	MAINT. RATE	ANNUAL MAINT. COST	AVERAGE ANNUAL MAINTENANCE COST: COST PER MILE (100 MILES)	COST PER KM (160 KM)
4,000	$136,309,000	3%	$4,089,000	$40,900	$25,600
8,000	$138,898,000	3%	$4,167,000	$41,700	$26,000
12,000	$230,554,000	3%	$6,917,000	$69,200	$43,200
25,000	$235,732,000	3%	$7,072,000	$70,700	$44,200

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 221 - COST FOR VEHICLE ENERGY SHEET 5

COST ELEMENTS

1. VEHICLE ENERGY COSTS PER VEHICLE

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
THE VEHICLE ENERGY REQUIRED FOR THE 100 STRAIGHT MILES OF THE BASELINE PARAMETERS IS 5,775 KW PER VEHICLE.	KWH	37,941,750	$0.0852	$3,232,640

1 VEHICLE X 5,775 KW = 5,775 KW PER HOUR

OPERATING HOURS = 18 X 365 = 6,570 HOURS PER YEAR

TOTAL ANNUAL ENERGY = 37,941,750 KWH PER YEAR

TOTAL ANNUAL ENERGY COST PER VEHICLE BASED ON 6,570 OPERATING HOURS PER YEAR $3,232,640

2. VEHICLE ENERGY COSTS BY THROUGHPUT

				AVERAGE ANNUAL VEHICLE ENERGY COST	
THROUGHPUT	NUMBER OF VEHICLES	ANNUAL COST PER VEHICLE	ANNUAL COST ALL VEHICLES	COST PER MILE (100 MILES)	COST PER KM (160 KM)
4,000	20	$3,232,640	$64,653,000	$646,500	$404,100
8,000	40	$3,232,640	$129,306,000	$1,293,100	$808,200
12,000	60	$3,232,640	$193,958,000	$1,939,600	$1,212,200
25,000	120	$3,232,640	$387,917,000	$3,879,200	$2,424,500

TOTAL ESTIMATED ANNUAL OPERATING AND MAINTENANCE INCREMENTAL COST TO INCREASE CAPACITY 4,000 TO 8,000 TO 12,000 TO 25,000

OPERATING AND MAINTENANCE COST ELEMENT: WBS NO. 231 - ON-BOARD PERSONNEL COSTS SHEET 6

COST ELEMENTS

1. ON-BOARD PERSONNEL COSTS PER VEHICLE

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
ON-BOARD PERSONNEL REQUIRMENTS	HR	8,760	$30.00	$262,800
SUPERVISION & SUPPORT LABOR FOR ON-BOARD PERSONNEL	HR	438	$30.00	$13,140

BASED ON THE FOLLOWING CRITERIA:
AVERAGE TRIP LENGTH OF 3 HOURS
TOTAL OF 1 VEHICLES FOR 100 MILES
1 OPERATOR/ATTENDANT PER VEHICLE TRIP
3 LABOR SHIFTS AT 8 HOURS EACH

1 OPERATOR/ATTENDANT X 3 SHIFTS = 24 HOURS PER VEHICLE DAY
1 VEHICLE X 24 HOURS/DAY X 365 DAYS = 8,760

ALLOW 5% OF ON BOARD PERSONNEL = 438

TOTAL ESTIMATED ANNUAL ON-BOARD PERSONNEL COST PER VEHICLE $275,940

USE 276,000

2. ON-BOARD PERSONNEL COSTS BY THROUGHPUT

THROUGHPUT	NUMBER OF VEHICLES	ANNUAL COST PER VEHICLE	ANNUAL COST ALL VEHICLES	AVERAGE ANNUAL VEHICLE ENERGY COST: COST PER MILE (100 MILES)	COST PER KM (160 KM)
4,000	20	$276,000	$5,520,000	$55,200	$34,500
8,000	40	$276,000	$11,040,000	$110,400	$69,000
12,000	60	$276,000	$16,560,000	$165,600	$103,500
25,000	120	$276,000	$33,120,000	$331,200	$207,000

FILE 6869-CE15

BASELINE ROUTE - SEPTEMBER 1992

MAGLEV COST ESTIMATION SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED CONSTRUCTION COST PER BASELINE PARAMETERS SHEET 1

MISCELLANEOUS CAPITAL COST ITEMS

COST ELEMENTS

WBS NO.	DESCRIPTION	TOTAL COST PER EACH
1215	MAGNETIC SWITCH COST	$6,027,000
1216	CROSS OVER COST	$11,808,000
162	STATION BUILDING COST	$12,500,000

TOTAL ESTIMATED CAPITAL COST SHEET 2

CAPITAL COST ELEMENT: WBS NO. 1215 - MAGNETIC SWITCH COST

COST ELEMENTS MAGNETIC SWITCH FOR MIN-B RIDE QUALITY AT A SPEED OF 100 M/S
ALUMINUM GUIDEWAY, 17 FT (5.18 M) HEIGHT & 1,775 FT (541 M) LENGTH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
MAGNETIC SWITCH				
FOUNDATION EXCAVATION	CY	1,833	$1.95	$3,574
FOUNDATION CONCRETE	CY	1,028	134.75	138,523
FOUNDATION BACKFILL	CY	805	8.90	7,162
CONCRETE COLUMNS	CY	281	729.96	205,118
CONCRETE CROSS BEAMS	CY	1,338	531.09	710,604
ALUMINUM GUIDE RAIL MATERIAL/FABRICATION	TN	491	8276.16	4,063,594
ALUMINUM GUIDE RAIL DELIVER/ERECTION	TN	491	240.46	118,068
ALUMINUM GUIDE RAIL ALIGNMENT	LF	3,550	1.50	5,325
MOBILIZATION/DEMOBILIZATION	LS	5%		262,598
SUBTOTAL				5,514,566
LSM WINDING - STRAIGHT SECTION COST PER WBS NO. 1526	M	541	473.60	256,219
LSM WINDING - ALLOW EQUAL AMOUNT FOR ADDITIONAL COSTS	M	541	473.60	256,219
TOTAL ESTIMATED CONSTRUCTION COST				6,027,004
				USE $6,027,000

MAGLEV COST ESTIMATION | SYSTEM CONCEPT DEFINITION

TOTAL ESTIMATED CAPITAL COST | SHEET 3

CAPITAL COST ELEMENT: WBS NO. 1216 - CROSS OVER COST

COST ELEMENTS — CROSS OVER FOR MIN-B RIDE QUALITY AT A SPEED OF 100 M/S
ALUMINUM GUIDEWAY, 17 FT (5.18 M) HEIGHT & 1,775 FT (541 M) LENGTH

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
CROSS OVER				
FOUNDATION EXCAVATION	CY	3,265	$1.95	$6,367
FOUNDATION CONCRETE	CY	1,828	134.69	246,222
FOUNDATION BACKFILL	CY	1,426	8.90	12,696
CONCRETE COLUMNS	CY	373	728.30	271,655
CONCRETE CROSS BEAMS	CY	1,114	531.16	591,716
ALUMINUM GUIDE RAIL MATERIAL/FABRICATION	TN	811	8276.10	6,711,919
ALUMINUM GUIDE RAIL DELIVER/ERECTION	TN	811	240.46	195,015
ALUMINUM GUIDE RAIL ALIGNMENT	LF	5,131	1.50	7,697
MOBILIZATION/DEMOBILIZATION	LS	5%		402,164
SUBTOTAL				8,445,451
LSM WINDING - STRAIGHT SECTION COST PER WBS NO. 1526	M	1,082	1553.89	1,681,308
LSM WINDING - ALLOW EQUAL AMOUNT FOR ADDITIONAL COSTS	M	1,082	1553.89	1,681,308
TOTAL ESTIMATED CONSTRUCTION COST				11,808,067
				USE $11,808,000

TOTAL ESTIMATED CAPITAL COST SHEET 4

CAPITAL COST ELEMENT: WBS NO. 162 - STATION BUILDING COST

COST ELEMENTS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	TOTAL
STATION BUILDING (MAG PORT) COST	GROSS SF.	85,000	$145.00	$12,325,000
ALLOWANCE FOR SITE WORK & SITE UTILITIES	LUMP SUM	1	175,000	175,000
TOTAL ESTIMATED CONSTRUCTION COST PER STATION	AVG. GROSS SF	85,000	$147.00	$12,500,000

NOTE STATION ESTIMATE BASED ON THE FOLLOWING:

1. GUIDEWAY COSTS EXCLUDED.
2. NO PROTECTION OR RELOCATION OF EXISTING FACILITIES REQUIRED.

ESTIMATING BACK-UP DATA AND INFORMATION

ESTIMATING BACK-UP DATA — PAGE 1

Client: MAGNEPLANE INTL.
Project: MAGLEV
Location: U S A
Account: ALL ACCOUNTS

United Engineers & Constructors
WESTERN OPERATIONS
Job No.: 6069.002
Date: 17-Jul-92
Priced By: WWS

DESCRIPTION	QTY	UofM	UNIT RATE	TOTAL
FOOTING EXCAVATION	8,184	CY	$2	$15,964
FOOTING BACKFILL	4,682	CY	$9	$41,669
FOOTING CONCRETE	3,502	CY	$135	$471,868
CONCRETE COLUMNS	1,109	CY	$729	$808,241
CONCRETE CROSS BEAMS	2,464	CY	$531	$1,308,293
ALUM. GUIDE RAIL MATL/FABR	1,342	TN	$8,279	$11,111,035
ALUM. GUIDE RAIL DELIVER/ERECT	1,342	TN	$241	$322,813
ALUM. GUIDE RAIL ALIGN	10,560	LF	$1	$15,800
SUBTOTAL				$14,095,683
MOBILIZATION/DEMOBILIZATION			5%	$704,784

NOTE: COSTS PER MILE

TOTAL	$14,800,467

Client: MAGNEPLANE INTL
Project: MAGLEV
Location: U S A
Account: ALL ACCOUNTS LF = N/A
Facility: ALUM GUIDE RAIL DOUBLE, ELEV,30'SPAN X 17'H

United Engineers & Constructors

WESTERN OPERATIONS
Rev No.:
Job No.: 6809.002

Date: 17-Jul-92
Priced By: WWS

WBS	ACCT	Description	Quantity U/M	Manhours per unit	Manhours total	Manhours $/MH	MATL Unit	SUBS Unit	Compounded Mark-Ups 128.000%	Totals Labor	Totals Material	Totals Subs	Totals Total
	A	FOOTING EXCAVATION	8,164 CY	0.026	213	$23.75		0.93		$6,374		$9,590	$15,964
	A	FOOTING BACKFILL	4,682 CY	0.260	1,217	$23.75		0.89		$36,419		$5,250	$41,669
	B	FOOTING CONCRETE	3,502 CY	1.180	4,133	$23.75	73.00	5.9		$123,680	$322,151	$26,037	$471,868
	B	CONCRETE COLUMNS	1,109 CY	7.350	8,151	$23.06	383.00	26		$236,729	$535,181	$36,331	$808,241
	B	CONCRETE CROSS BEAMS	2,464 CY	10.950	26,981	$23.06	149.00	20		$783,609	$462,591	$62,093	$1,308,293
	C	ALUM. GUIDE RAIL MATL/FABR	1,342 TN				6571.00				$11,111,035		$11,111,035
	C	ALUM. GUIDE RAIL DELIVER/ERE	1,342 TN	6.656	8,932	$23.75		32.836		$267,290		$55,523	$322,813
	C	ALUM. GUIDE RAIL ALIGN	10,560 LF	0.050	528	$23.75				$15,800			$15,800
SUBTOTAL					50,155					$1,469,901	$12,430,958	$194,824	$14,095,683
		MOBILIZATION/DEMOBILIZATION	5%		2,508					$73,495	$621,548	$9,741	$704,784

NOTE: COSTS PER MILE

TOTAL ALUM GUIDE RAIL DOUBLE, ELEV,30'SPA	52,663	$29.31		$1,543,396	$13,052,506	$204,565	$14,800,467

ESTIMATING BACK-UP DATA – PAGE 2

ESTIMATING BACK-UP DATA — PAGE 3

5007 REV. 7/79 GENERAL COMPUTATION SHEET

United Engineers & Constructors
A Raytheon Company

CALC. SET NO.		REV	COMP. BY	CHK'D. BY
PRELIM.		0	PARKER	
FINAL			DATE 7-13-92	DATE
VOID				
SHEET	OF	1	PARKER	
J.O.	6869002		DATE 7-17	DATE

NAME OF COMPANY MAGNEPLANE UNIT/S

SUBJECT ESTIMATE

FORMAT FOR TYPICAL DUAL GUIDEWAY (ALUMINUM BOX BEAM)

ALUM ELEVATED DUAL
HT = 17'
SPAN = 30'

	UNITS		QTY/MILE
FOOTING (BY BCI)			
STRUCT. EXCAVATION	CY	46.5 x 5280/30	8184
FORM & POUR	CY	26.6 x "	4682
COMPACTED BACKFILL	CY	19.9 x "	3502
CONCRETE COLUMNS FORM & POUR	CY	6.30 x 5280/30	1109
CONCRETE CROSS BEAMS FORM & POUR	CY	14 x 5280/30	2464
GUIDEWAY TROUGH			
FABRICATE ALUM BOX BEAMS	TN	~~564~~ 671 x 2	~~1128~~ 1342
DELIVER & ERECT BOX BEAMS	TN	~~564~~ 671 x 2	~~1128~~ 1342
ALIGNMENT	LF	2 x 5280	10560
*			
SUBTOTAL			
MOBILIZATION/DEMOBILIZATION	%		
TOTAL			

[NOTE CONTINGENCY ADDED LATER]

* NOTE: LSM HAS NOT BEEN INCLUDED HERE AS PER THE PARSONS/VOLPE DOCUMENT, THE LONG STATOR WINDING WAS IN "GUIDEWAY ELECTRIFICATION SECTION UNDER WBS 1526.

FORM 5007 REV 1/79 GENERAL COMPUTATION

United Engineers & Constructors
A Raytheon Company

PAGE 4

DISCIPLINE:

NAME OF COMPANY _____ UNIT/S _____

SUBJECT _____

CALC. SET NO	REV	COMP. BY	CHK'D.
PRELIM.	0	DATE	DATE
FINAL			
VOID			
SHEET OF		DATE	DATE
J.O.			

MTO FOR CONCRETE COLUMNS & CROSS BEAM

30' SPAN — 45' SPAN

COLS $(2)\frac{33^2\pi}{4(144)}(17+1-3.6)/27 = 6.3\ cy$ — $(2)\frac{36^2\pi}{4(144)}(17+1-36)/27 = 7.54$

BEAM $137\ SF\left(\frac{33}{12}\right)/27 = 14.0\ cy$ — $14\left(\frac{36}{33}\right) = 15.3\ cy$

MAGLEV
BCI Project No. 7901
Quanity Summary
Quanities based upon loading condition 3 as listed on the footer design summary
All quanities are listed in cubic yards.
All quanities based on depth of 3.5 feet to the bottom of the footer.
Thickness of footer used for quanities is 2.5 feet.
Excavation quanities based on 2 ft clearence on all sides.

	Quanities, CYS	
Description	30 Ft. Span	45 Ft. Span
Excavation	46.5	44.1
Form & Pour of footer	26.6	25.0
Backfill - Compacted	19.9	19.1

PAGE 6

MAGLEV
BCI Project No. 7901
Footer Design Summary Sheet
Aluminum Box Beam - Double Guideway
Load and Load Cases per Don Parker at UEC
Maximum allowable soil bearing capacity = 3 KIPS/FT

Load Conditions and Notes	30 Ft Span		45 Ft Span	
	B (ft)	L (ft)	B (ft)	L (ft)
1 - All loads considered Resultant force falls within the kern.	45	36	44	35
2 - No emergency loads considered - (earthquake, wind, or braking) Resultant force falls within the kern.	8.5	18.5	9	16
3 - All loads considered. Resultant force allowed to fall outside of the kern for emergency cases.	15.5	18.5	15	18

BANKED GUIDEWAY COST ESTIMATE

Method used to establish pricing of banked guideway sections:

1) Determine the cost of a straight section

2) Design guideway and support for the maximum 35° bank

   - Loading from vehicle based on information from Mike Judd with semi gap of 1.0 m on inside of curved guideway
   - Foundation design by BCI based on loadings from UE&C.

3) For each of the guideway components, determine the quantities for the 35° bank and establish the ratios of 35° bank to straight section

   - Note that the inside and outside box beams have been calculated separately as the configuration of each changes differently in the banked curve

4) Establish "weighting" factors for each component as follows (based on straight section costs)

		Factors
Foundation	$15,964 + 41,669 + 471,868	0.037
Columns	$808,241	0.057
Cross Beams	$1,308,293	0.093
Box Beam Inside	$(11,111,035 + 322,813)/2	0.406
Box Beam Outside	" "	0.406
Alignment	$15,800	0.001
	$14,095,683	1.000

5) Determine variation of each component with bank angle from 0° to 24°. Graph this variation (plot ratio as a function of bank angle). [See p. 3]

6) Determine cost ratio of the banked sections to the straight section for each of the angles encountered in the SST. Do this by multiplying the ratio for each component by the weighting factor. The sum of these values will be the ratio of banked cost to the straight section cost. [See p. 4]

The results are as follows:

Bank °	Ratio	Multiplier (Ratio - 1.00)
5	1.050	0.050
10	1.099	0.099
14	1.176	0.176
15	1.194	0.194
16	1.214	0.214
18	1.254	0.254
19	1.274	0.274
20	1.293	0.293
21	1.315	0.315
23	1.359	0.359
24	1.380	0.380

7) On a spreadsheet, determine the extra cost of the banked sections as follows:

a) For each curve are multiply arc length by the multiplier shown in step 6 [See P 6]
b) Sum these figures for all the circular curve arcs: 4,001.
c) For each curve, multiply the taper (or spiral) length by the multiplier shown below. The multiplier takes into account that there are two tapers at each curve (one at each end of the circular arc). This multiplier is an average of the values from 0° to the bank angle under consideration [see P. 5]

Bank Angle	Multiplier for Taper
10	.110
14	.164
15	.179
16	.195
18	.227
19	.244
20	.261
21	.279
23	.315
24	.333

d) Sum the figures obtained in step 7 c) = 5,015.

8) The extra cost of all the curves (including spirals) is then obtained by multiplying the sum of 7 b) and 7 d) by the per meter straight section cost. The sum of 7 b) and 7 d) = 9,016.

Note also that the Σ of all arcs = 10,529 m therefore the average extra cost for an arc section = $\frac{4001}{10529}$ = 38% more than a straight section

Similarly spiral sections cost $\frac{5015}{15,860}$ = 31.6% / 2 = 15.8% more.

PAGE 9

FORM 5007 REV. 7/78 GENERAL COMPUTATION SHEET

(DISCIPLINE)

United Engineers & Constructors

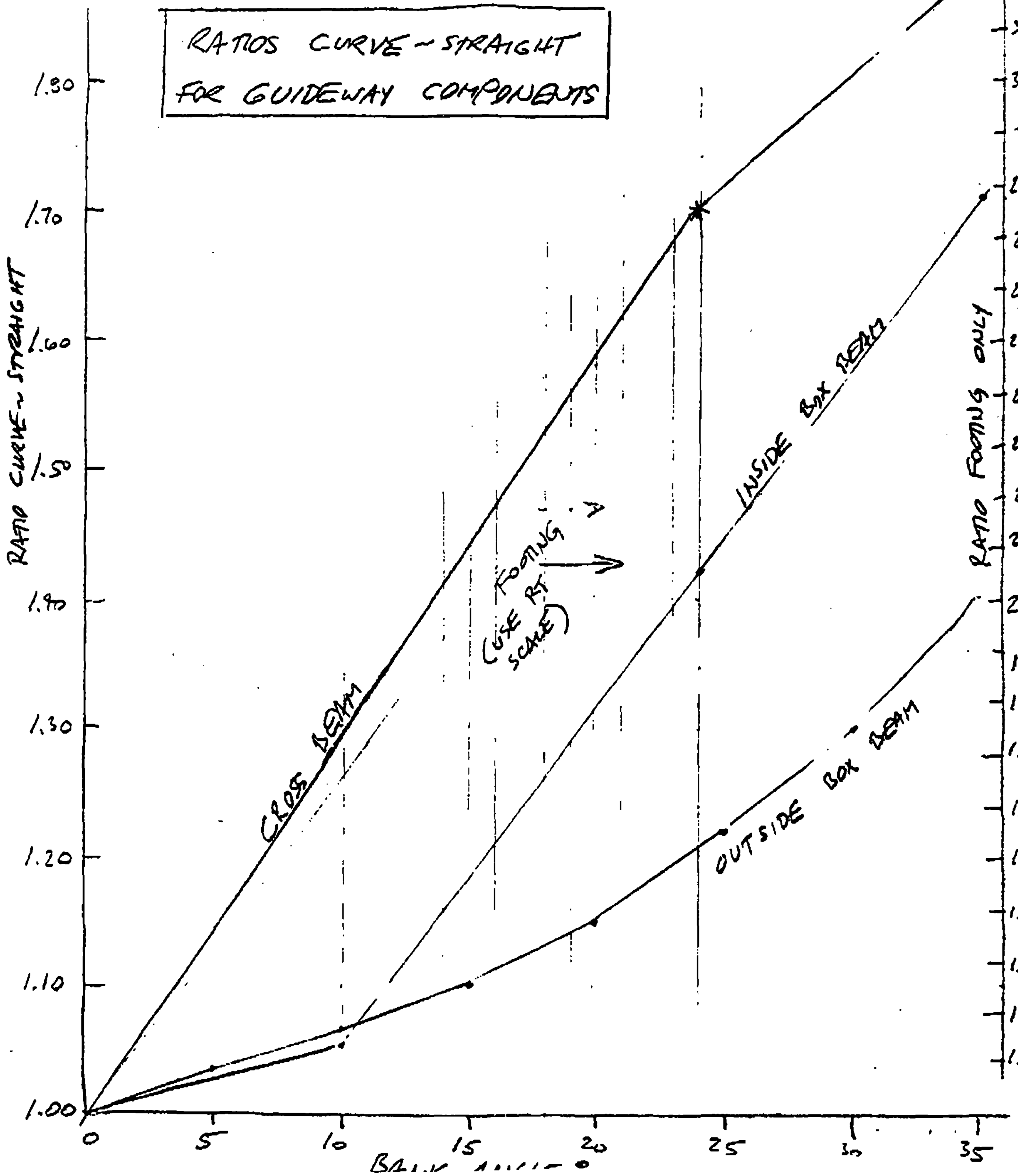
A Raytheon Company

CALC SET NO.		REV	COMP. BY	CHK'D. BY
PRELIM.		0	PARKER	
FINAL			DATE 7-29-92	DATE
VOID				
SHEET OF			DATE	DATE
J.O				

NAME OF COMPANY ______ UNIT/S ______

SUBJECT MAGLEV

RATIOS CURVE ~ STRAIGHT FOR GUIDEWAY COMPONENTS



WEIGHTED FACTORS FOR CURVES

	WEIGHTING FACTOR	10 DEG RATIO	WTD FACTOR	14 DEG MULTP.	WTD FACTOR	15 DEG MULTP.	WTD FACTOR	16 DEG MULTP.	WTD FACTOR	18 DEG MULTP.	WTD FACTOR	19 DEG MULTP.	WTD FACTOR
FOUND	0.037	1.650	0.061	1.930	0.071	1.980	0.073	2.070	0.077	2.180	0.081	2.260	0.084
COLUMNS	0.057	1.000	0.057	1.000	0.057	1.000	0.057	1.000	0.057	1.000	0.057	1.000	0.057
CROSS BM	0.093	1.300	0.121	1.410	0.131	1.440	0.134	1.470	0.137	1.530	0.142	1.560	0.145
INS GUIDE	0.406	1.050	0.426	1.160	0.471	1.185	0.481	1.210	0.491	1.265	0.514	1.290	0.524
OS GUIDE	0.406	1.065	0.432	1.095	0.445	1.103	0.448	1.113	0.452	1.132	0.460	1.142	0.464
ALIGN	0.001	1.000	0.001	1.000	0.001	1.000	0.001	1.000	0.001	1.000	0.001	1.000	0.001
	1.000		1.099		1.176		1.194		1.214		1.254		1.274

WEIGHTED FACTORS FOR CURVES

	WEIGHTING FACTOR	20 DEG MULTP.	WTD FACTOR	21 DEG MULTP.	WTD FACTOR	23 DEG MULTP.	WTD FACTOR	24 DEG MULTP.	WTD FACTOR	5 DEG MULTP.	WTD FACTOR
FOUND	0.037	2.330	0.086	2.380	0.088	2.530	0.094	2.600	0.096	1.330	0.049
COLUMNS	0.057	1.000	0.057	1.000	0.057	1.000	0.057	1.000	0.057	1.000	0.057
CROSS BM	0.093	1.590	0.148	1.620	0.151	1.680	0.156	1.700	0.158	1.140	0.106
INS GUIDE	0.406	1.315	0.534	1.340	0.544	1.393	0.566	1.421	0.577	1.025	0.416
OS GUIDE	0.406	1.150	0.467	1.168	0.474	1.195	0.485	1.210	0.491	1.035	0.420
ALIGN	0.001	1.000	0.001	1.000	0.001	1.000	0.001	1.000	0.001	1.000	0.001
	1.000		1.293		1.315		1.359		1.380		1.050

FORM 3007 REV 7/79 GENERAL COMPUTATION SHEET PAGE 11

(DISCIPLINE)

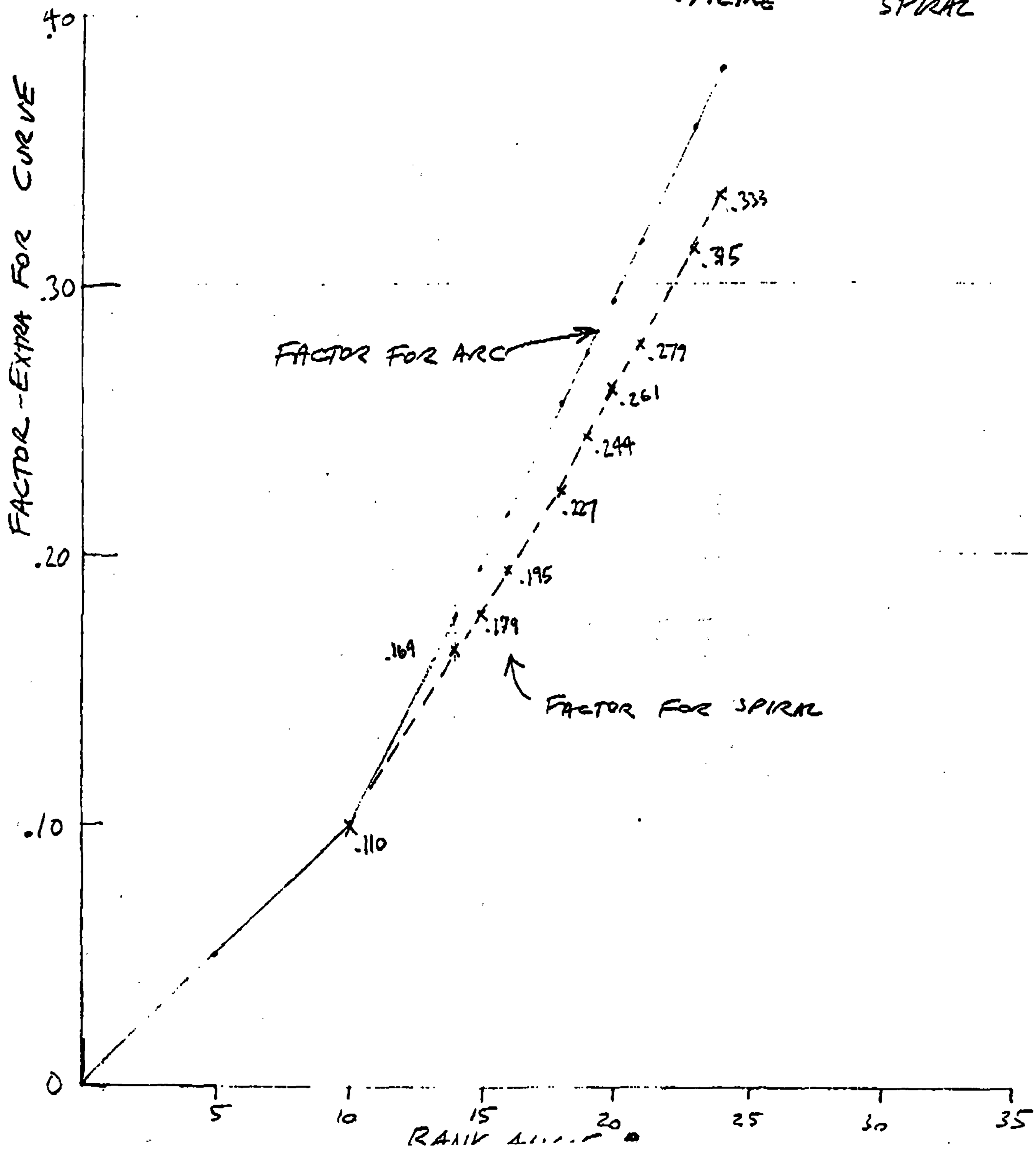
United Engineers & Constructors
A Raytheon Company

CALC. SET NO		REV	COMP. BY	CHK'D. BY
PRELIM.		0	PARKER	
FINAL			DATE 7-27-92	DATE
VOID				
SHEET OF			DATE	DATE
J.O				

NAME OF COMPANY ________ UNIT/S ________

SUBJECT MAGLEV

FACTOR - EXTRA COST FOR CURVE/METRE FOR ARC & SPIRAL



COMPILATION OF CURVE COSTS FOR THE HYPOTHETICAL ROUTE *PAGE 12*

POSITION (STATION)	PI #	L ea spiral	L ea arc	BANK AGL	FACTOR for spiral	FACTOR for arc	L SPIRAL* FACTOR	L ARC* FACTOR
9	1	213	66	24	0.333	0.380	70.929	25.080
16	2	175	0	20	0.261	0.293	45.675	0.000
22	3	282	337	24	0.333	0.380	93.906	128.060
33	4	337	536	24	0.333	0.380	112.221	203.680
40	5	261	681	24	0.333	0.380	86.913	258.780
54	6	301	257	24	0.333	0.380	100.233	97.660
62	7	105	0	14	0.164	0.176	17.220	0.000
72	8	320	466	24	0.333	0.380	106.560	177.080
81	9	337	361	24	0.333	0.380	112.221	137.180
96	10	209	0	21	0.279	0.315	58.311	0.000
101	11	238	198	24	0.333	0.380	79.254	75.240
107	12	261	629	24	0.333	0.380	86.913	239.020
117	13	279	0	23	0.315	0.359	87.885	0.000
124	14	282	207	24	0.333	0.380	93.906	78.660
132	15	282	573	24	0.333	0.380	93.906	217.740
144	16	337	361	24	0.333	0.380	112.221	137.180
154	17	175	0	16	0.227	0.214	39.725	0.000
166	18	209	0	19	0.244	0.274	50.996	0.000
173	19	261	53	24	0.333	0.380	86.913	20.140
182	20	337	187	24	0.333	0.380	112.221	71.060
188	21	157	0	15	0.179	0.194	28.103	0.000
198	22	337	12	24	0.333	0.380	112.221	4.560
206	23	238	67	24	0.333	0.380	79.254	25.460
212	24	183	0	18	0.227	0.254	41.541	0.000
217	25	105	0	14	0.164	0.176	17.220	0.000
221	26	337	12	24	0.333	0.380	112.221	4.560
231	27	261	472	24	0.333	0.380	86.913	179.360
238	28	320	701	24	0.333	0.380	106.560	266.380
243	29	261	53	24	0.333	0.380	86.913	20.140
256	30	337	187	24	0.333	0.380	112.221	71.060
262	31	279	0	23	0.315	0.359	87.885	0.000
273	32	282	85	24	0.333	0.380	93.906	32.300
278	33	282	207	24	0.333	0.380	93.906	78.660
285	34	261	158	24	0.333	0.380	86.913	60.040
294	35	301	187	24	0.333	0.380	100.233	71.060
304	36	262	0	21	0.279	0.315	73.098	0.000
313	37	337	12	24	0.333	0.380	112.221	4.560
324	38	262	0	21	0.279	0.315	73.098	0.000
333	39	157	0	15	0.179	0.194	28.103	0.000
340	40	320	73	24	0.333	0.380	106.560	27.740
350	41	175	0	16	0.195	0.214	34.125	0.000
356	42	70	0	10	0.110	0.099	7.700	0.000
365	43	314	0	24	0.333	0.380	104.562	0.000
373	44	337	710	24	0.333	0.380	112.221	269.800
380	45	282	268	24	0.333	0.380	93.906	101.840
388	46	301	117	24	0.333	0.380	100.233	44.460
398	47	175	0	16	0.195	0.214	34.125	0.000
405	48	369	154	24	0.333	0.380	122.877	58.520
420	49	584	202	24	0.333	0.380	194.472	76.760
434	50	754	119	24	0.333	0.380	251.082	45.220
449	51	953	1,141	24	0.333	0.380	317.349	433.580
469	52	1,066	680	24	0.333	0.380	354.978	258.400
SUMS		15,860.000	10,529.000				5,014.849	4,001.020

PAGE 13

Client: MAGNEPLANE INTL.
Project: MAGLEV
Location: U S A
Account: ALL ACCOUNTS
Facility: TUNNEL BORED DOUBLE
WBS 1234-10 10M DIA.

United Engineers & Constructors
WESTERN OPERATIONS
Job No.: 6869.002

Date: 17-Jul-92
Priced By: WWS

WBS	DESCRIPTION	QTY	UofM	UNIT RATE	TOTAL
1233-10	EXCAVATION	288,000	CY	$66	$19,014,912
1233-10	LINER	718,080	SF	$8	$6,030,468
1233-10	ROCK BOLTS	42,240	EA	$179	$7,550,928
1233-10	HAUL ROCK	288,000	CY	$9	$2,576,448
1233-10	WATER PROOFING	2	LOT	$693,756	$1,387,512
1233-10	DRAINAGE	10,560	LF	$23	$239,501
1233-10	SURVEY	2	LOT	$23,940	$47,880
1233-10	FOOTING/WALKWAY	11,616	CY	$118	$1,373,311
1233-10	CATWALK	10,560	LF	$52	$552,515
1233-10	LIGHTING	10,560	LF	$47	$496,565
1233-10	VENTILATION	10,560	LF	$141	$1,487,566
CRAD	STR STEEL CRADLE	704	TN	$2,105	$1,481,673
AGRS	ALUM. GUIDE RAIL	1,128	TN	$8,279	$9,339,231
AGRS	ALUM. GUIDE RAIL	1,128	TN	$241	$271,346
AGRS	ALUM. GUIDE RAIL	10,560	LF	$1	$15,800
SUBTOTAL					$51,865,656
	MOBILIZATION & DEMOBILIZATION			5%	$2,593,283
TOTAL					$54,458,939

NOTES:
(1) COSTS PER MILE
(2) EXCLUDES CONTINGENCY WHICH WILL BE ADDED ON GRAND TOTAL OF ESTIMATE (WITH OTHER COMPONENTS)

Client: MAGNEPLANE INTL.
Project: MAGLEV
Location: U S A
Account: ALL ACCOUNTS
Facility: TUNNEL BORED DOUBLE
WBS 1234-10 10M DIA.

LF = N/A

United Engineers & Constructors

WESTERN OPERATIONS

Rev No.:
Job No.: 6869.002

Date: 17-Jul-92
Priced By: WWS

WBS	ACCT	Description	Quantity U/M	Manhours per unit	Manhours total	Manhours $/MH	MATL Unit	SUBS Unit (Compounded Mark-Up 126.000%)	Totals Labor	Totals Material	Totals Subs	Totals Total
1233-10	A	EXCAVATION	268,000 CY					52.4			$19,014,912	$19,014,912
1233-10	A	LINER	716,080 SF	0.192	137,512	$21.75	2.50		$3,768,516	$2,281,952		$6,030,468
1233-10	A	ROCK BOLTS	42,240 EA	4.500	190,080	$21.75	44.00		$5,209,142	$2,341,786		$7,550,928
1233-10	A	HAUL ROCK	268,000 CY					7.1			$2,578,448	$2,576,448
1233-10	A	WATER PROOFING	2 LOT					550600			$1,387,512	$1,387,512
1233-10	A	DRAINAGE	10,560 LF	0.500	5,280	$26.00	5.00		$172,973	$66,528		$239,501
233-10	A	SURVEY	2 LOT					19000			$47,880	$47,880
233-10	B	FOOTING/WALKWAY	11,616 CY	1.000	11,616	$21.75	69.24	2.84	$318,336	$1,013,408	$41,567	$1,373,311
1233-10	C	CATWALK	10,560 LF	0.300	3,168	$21.75	35.00		$86,819	$465,696		$552,515
1233-10	F	LIGHTING	10,560 LF	0.950	10,032	$25.60	13.00		$323,592	$172,973		$496,565
1233-10	K	VENTILATION	10,560 LF	1.600	16,896	$25.50	71.00		$542,868	$944,698		$1,487,566
RAD	C	STR STEEL CRADLE	704 TN	12.200	8,589	$21.75	1358.00	47	$235,382	$1,204,600	$41,681	$1,481,673
GRS	C	ALUM. GUIDE RAIL	1,128 TN			$23.75	6571.00			$9,339,231		$9,339,231
GRS	C	ALUM. GUIDE RAIL	1,128 TN	6.656	7,508	$23.75		32.896	$224,677		$46,669	$271,346
GRS	C	ALUM. GUIDE RAIL	10,560 LF	0.050	528	$23.75			$15,600			$15,600
UBTOTAL					391,209				$10,898,105	$17,810,872	$23,156,679	$51,865,656
		MOBILIZATION & DEMOBILIZATION	5%		19,560				$544,905	$880,544	$1,157,834	$2,593,283
		TOTAL TUNNEL BORED DOUBLE			410,769	$27.66			$11,443,010	$18,701,416	$24,314,513	$54,458,939

NOTES:
(1) COSTS PER MILE
(2) EXCLUDES CONTINGENCY WHICH WILL BE ADDED ON GRAND TOTAL OF ESTIMATE (WITH OTHER COMPONENTS)

PAGE 1/4

ESTIMATED COST FOR 34.5 kV LINE - 7/24/92

34.5 kV Line Material	Unit Cost		Construction Costs :				
		Work Activities	Equipment / tools (per mile)	Labor (Manhours) per mile	Labor ($40/hr.)	Material Costs per mile	
50 ft. steel pole (direct embedded)	$1,100	•distribute poles	$1,200	200	$8,000	$43,540	
Steel 10 ft. Cross - arms	$165	•excavate holes	$2,200	220	$8,800		
Steel Brackets 6 ft.	$40	•frame str.	$1,400	280	$11,200		
Insulators :		•set str.	$4,950	220	$8,800		
•Pin Type	$30						
•Strain	$15	•stringing	$3,000	300	$12,000	$18,575	336.4 ACSR
						$37,282	795 ACSR
Miscellaneous Hardware	$250	•demobilize	$500	200	$8,000		
Wire : (per ft.)							
•7#9Alumiweld	$0.50	subtotals :	$13,250	1420	$56,800	$62,115	336.4 ACSR
•336.4 ACSR	$0.50					$80,822	795 ACSR
•795 ACSR	$1.09	equipment / labor totals	$70,050				
		total per mile cost		100 mile line			
		• 336.4 ACSR	$132,165	• 336.4 ACSR	$13,216,504		
		•795 ACSR	$150,872	•795 ACSR	$15,087,208		