Vertical Clearance Measurement & Posting of VC Signs

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ADOT- Bridge Management Section

Vertical clearance (VC) Measurement

Why measure vertical clearance under and over bridges?

1. The law
2. Public Safety
3. Over-sized loads

1. The Law: National Bridge Inspection Standards (NBIS), 23 Code of Federal Regulations (CFR) Part 650

(a)Each State transportation department must inspect, or cause to be inspected, all highway bridges located on public roads that are fully or partially located within the State's boundaries, except for bridges that are owned by Federal agencies.

§650.303 Applicability.

The National Bridge Inspection Standards (NBIS) in this subpart apply to all structures defined as highway bridges located on all public roads.

2. Public Safety

Interstate closure after an impact

3. Over-sized Loads (APS – $2.5X10^6$ Lbs - July 2007)

Vertical Clearance Measurement

Innovations aimed at controlling:

1. Inconvenience to public
2. Traffic control costs
3. Measurement time
4. Measurement error
5. Processing error/time
6. Difficulty using instrument
7. Cost by sharing applications

VC Measurement Methods

Bridge vertical underclearances measured from road surface to superstructure lowest member by variety of methods:

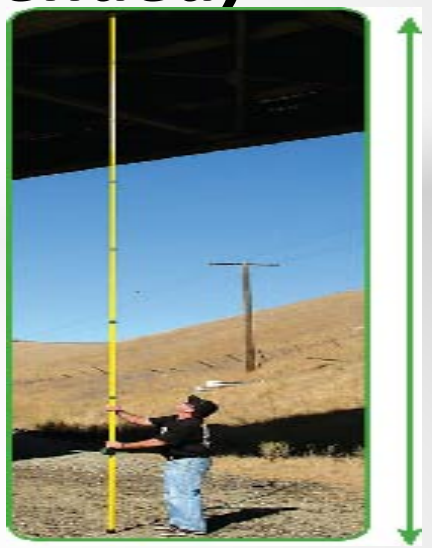
A. One Point - One Measurement (extended)

Measuring tapes

Surveying rods

Low cost

accuracy depending on the user



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VC Measurement Methods - Continued

B. One Point - One Measurement (projected)

hand-held ultrasonic distance measurement devices

PROS

Easy to handle

Low price (<$30 to $300)

Good distance (2' - 60')

Temperature (32° F - 109° F)

Resolution (1/2 Inch)

CONS

locking on to any false echoes

fluctuations in ambient temperature

different working conditions: surface roughness or suspended matter in the air

hand-held laser distance measurement devices

PROS

Easy to handle

Good distance (0' - 656')

Temperature (14° F - 122° F)

Resolution (0.04 Inch)

CONS

Moderate cost ($250 to $800)

Needs reflective surface

VC Measurement - Continued

C. One Station - Several Measurements

Theodolite and Level (Surveying)

Very expensive (especially when scanners added)

Need time and space for several set up points

VC Measurement - Continued

D. Fixed point light detection & ranging (LIDAR) scan

♣ High-precision clearance data

♣ Minimum vertical clearance locations are easily found.

♣Traffic noise may interfere with terrestrial LIDAR imaging

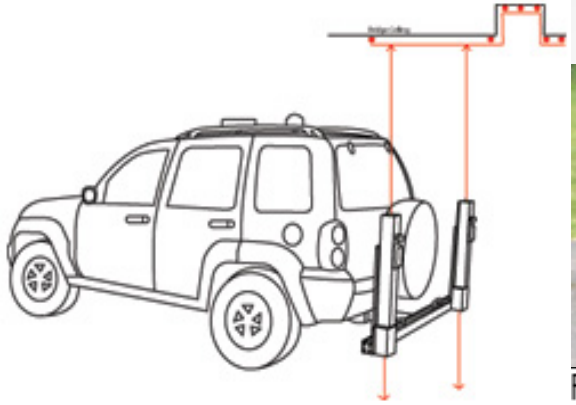
Field measurements of four bridges in North Carolina:

♦ LIDAR-based measurement techniques are valuable

♦ Deficient clearances cause collision damage and deviation of measurements from design criteria.

VC Measurement - Continued

E. Mobile laser measurement devices



Courtesy of Mandli Communications, Inc.

	FT widescreen
Processor	1GHz PowerPC G4 Processor with Velocity Engine
Memory	5 12MB of PC2700 DDR SDRAM
Storage	60GB 4200-rpm Ultra AT A/100 hard drive, 1x DVD-R, 8x CD-R, 4x CD-RW
Dimensions	1.0 in (2.6 cm) H x 15.4 in (39.2 cm) W x 10.2 in (25.9 cm) D, 6.8 lbs (3.1 kg) with battery

Vertical Accuracy	+/- 0.5" within the range of the system
DMI Accuracy	+/- 0.001 miles per mile
Relative Accuracy	+/- 0.5 max
Range of System	30' from sensor surface
Range of Downward Laser	22.15" - 2.95" from sensor surface

VC Measurement - Continued

F. Laser-radar cloud points

The *RIEGL* VMX-450 Mobile Laser Scanning System provides:

- extremely high measurement rates

collection rates up to 1.1 KHz (1,100,000 pts/sec)

- accurate

Precision of 5mm.

- feature-rich data
- high driving speeds.

at speeds up to 70mph

- Collects points in a circular (360-degree) pattern along the right-of-way from 2 scanner heads facing forward and to the rear of the vehicle in a crossing pattern. The laser captures 3D points along the ground of approximately 0.001 feet (adjustable to scan rates applicable for the project).
- manageable amount of data collected as point cloud data.

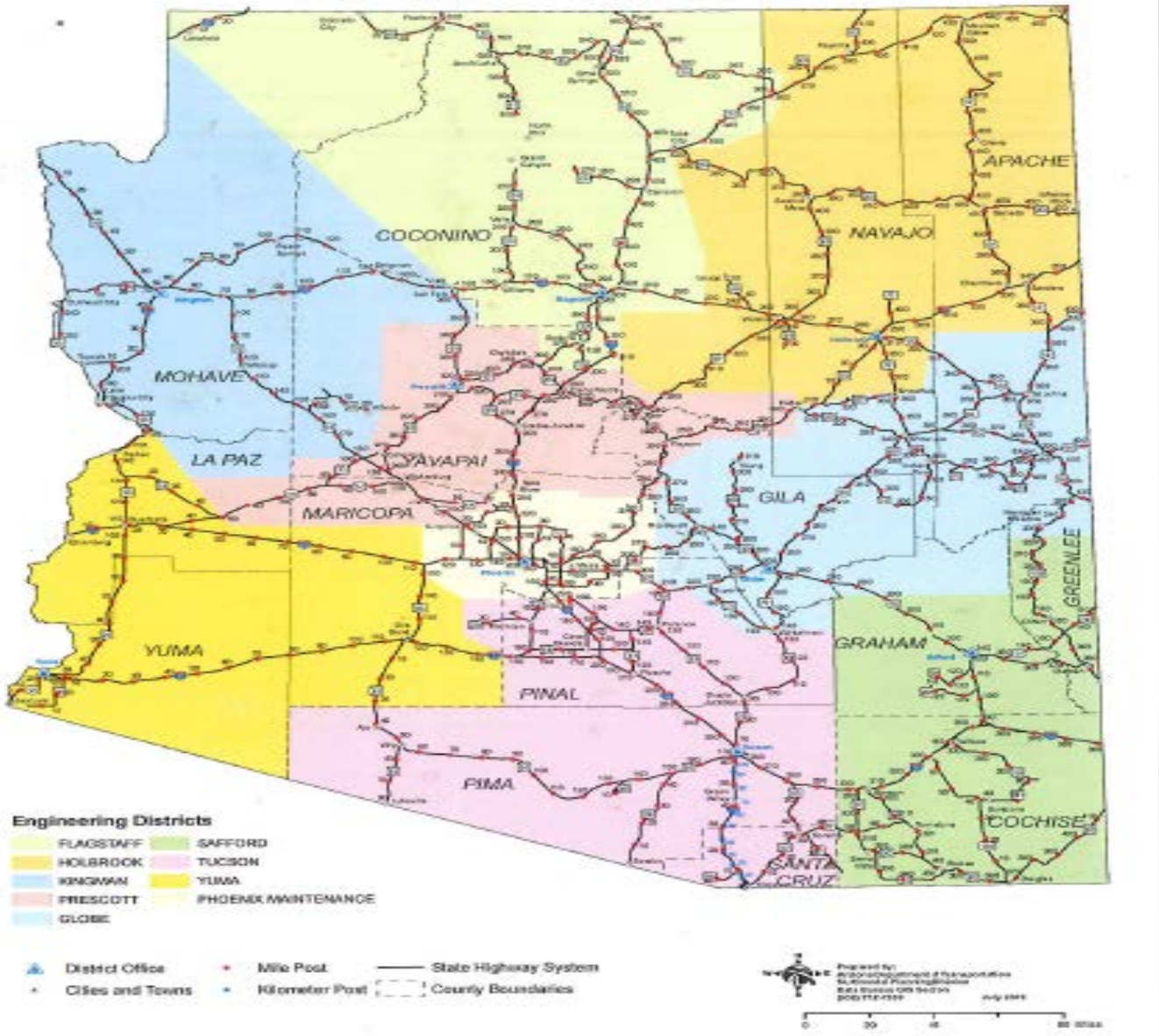
Reported LiDAR (VCMS) use by various DOTs

- Tennessee DOT, Hawaii DOT, Nevada DOT, Texas DOT: VCM & Asset management
- Caltrans: Contracted firm – VCM & Pavement Mgt.
- Ohio DOT: VCM

  (dozen structures a day) ➔3120/Year
- WSDOT: dedicated crew with VCMS

  (~$300/structure) ➔~ $1Mil/Year
- Conn. DOT: Mobile Laser – self-operated

ADOT Engineering and Maintenance Districts with State Milepost System

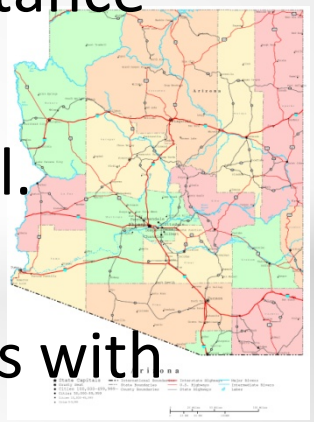


ADOT VC Measurement Status

- Inspection crews (5 teams, each 2 members)

  VC measurements during routine/initial inspections
- Instruments used range from tape measures to survey rods and more commonly laser distance finders.
- Routine inspections without traffic control. Measurement is made when safe.
- In-depth inspections by on-call consultants with traffic control

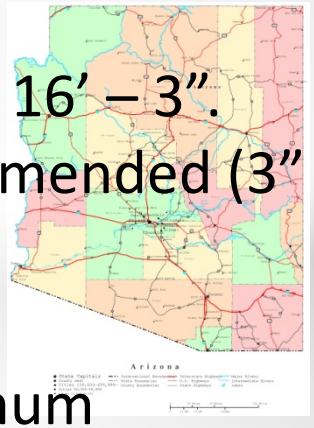
  VC measurements during inspection



Current ADOT policy regarding posting bridge vertical clearance signs

- Measurement made at traffic lane lines from the road surface to the bottom of the lowest member of the superstructure or substructure including the objects attached such as light fixtures.

- No posting of sign required if minimum vertical measurement for any traffic direction is greater than 16’ – 3”. For 16’-3”, posting of a sign reading 16’ – 0” is recommended (3” buffer zone for vehicle bounce).



- If the bridge is posted for a direction and the minimum measurement less 3” is less than the posted sign, the posted sign should be changed through a repair recommendation.

Lateral /vertical Clearance Measurement

ARIZONA DEPARTMENT OF TRANSPORTATION

BRIDGE GROUP
SUPPLEMENTAL PAGE TO BRIDGE INSPECTION REPORT
VERTICAL & HORIZONTAL CLEARANCE DIAGRAM

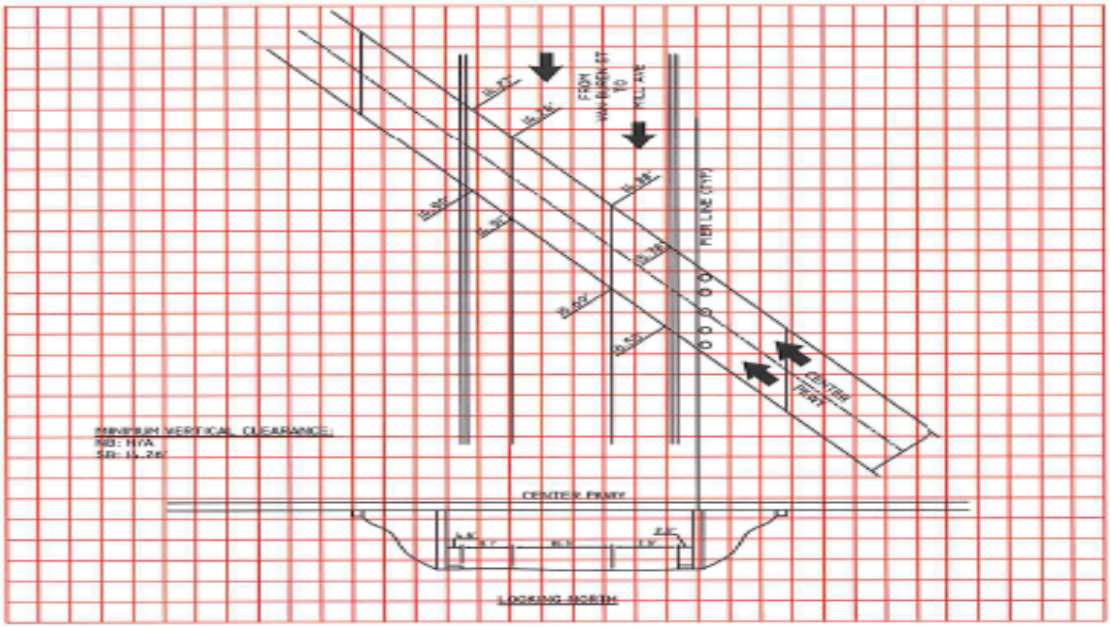
STRUCTURE NAME: CENTER PARKWAY OB WB

STRUCTURE NO.: 9952

LOCATION: TEMPE (ROUTE) (MILEPOST)

INSPECTION	25					
DATE	8/10/15					
INITIAL	DP/PN					
NEW/REVISED DIAGRAM	NEW					

NORTH



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Route	No. of Bridges	Miles
8	69	178.33
10	304	390.77
15	5	27.3
17	128	144.94
19	54	62.72
40	171	359.21
51	36	15.77
60	74	88.16
101	122	61.52
143	13	3.25
202	116	55.83
210	7	1.42
303	20	26.54

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Ideal VC Measurement System

- No **obstruction of target points** at the measurement time
- **Safe** for crew members
- **Automated recording** of measurements
- **Fast & accurate** measurements
- **Many points** under structure including the lowest elements
- Economical for both **few & many structures**

Problems:

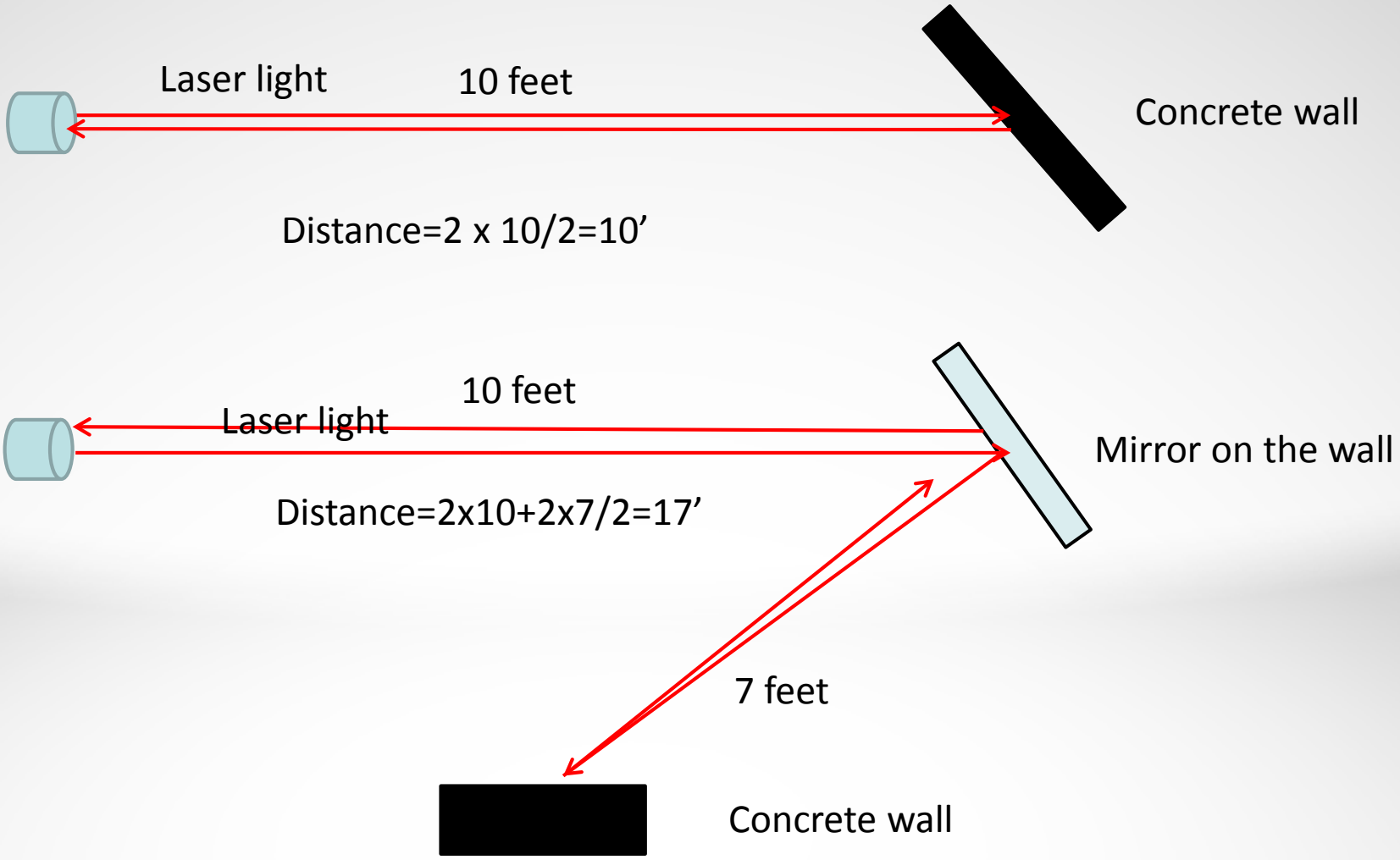
1. Laser distance measurement devices need reflective surface.
2. VC measurements at road surface
3. VC measurements subject to vehicular traffic and drivers' discretion.
4. VC measurement costs (including TC)

Opportunities

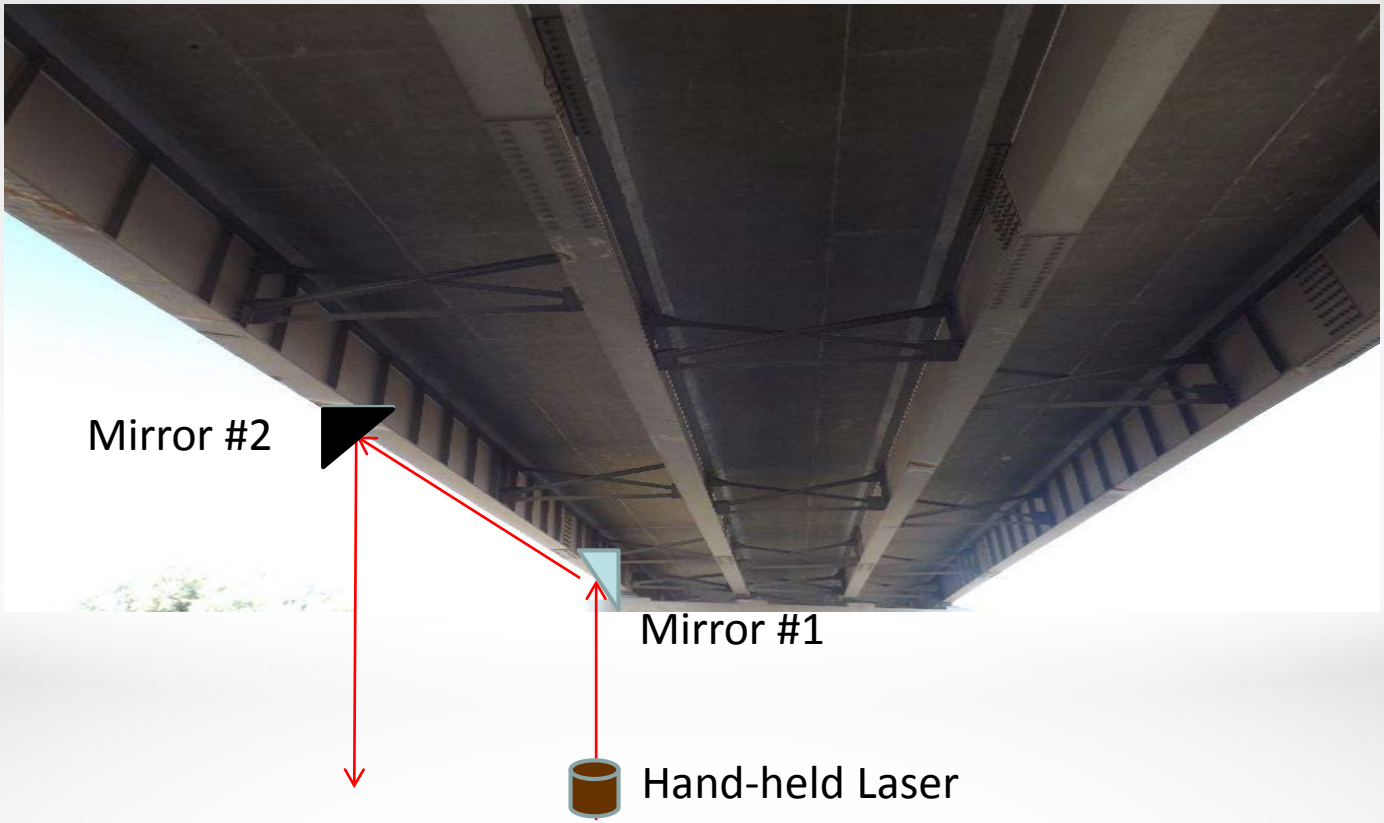
1. Use good reflective surface

2. Measure away from road surface or inside/near traffic lanes, i.e. use remote control measuring technique

Laser beam and reflective surfaces

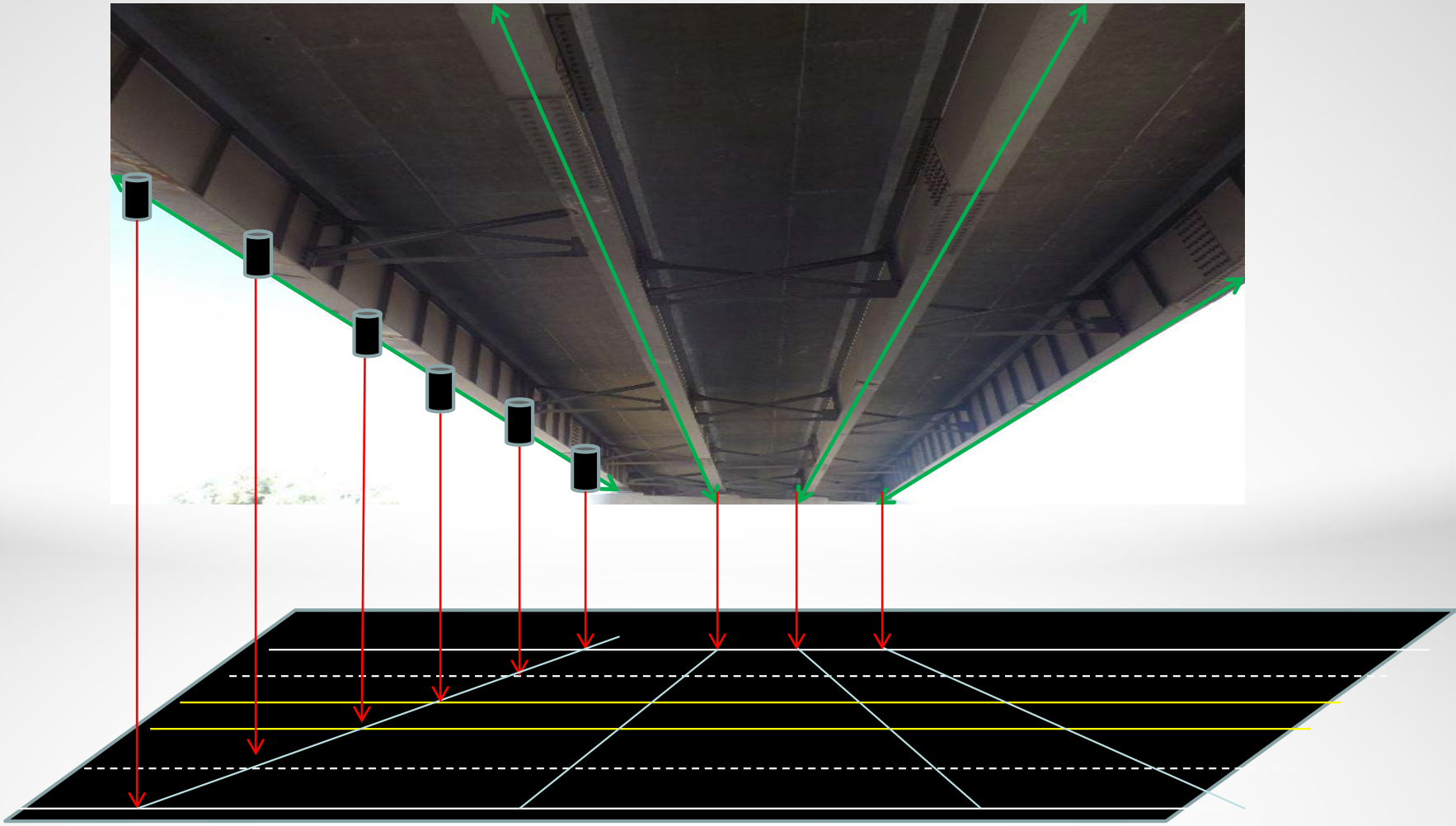


1. Application of a moving mirror

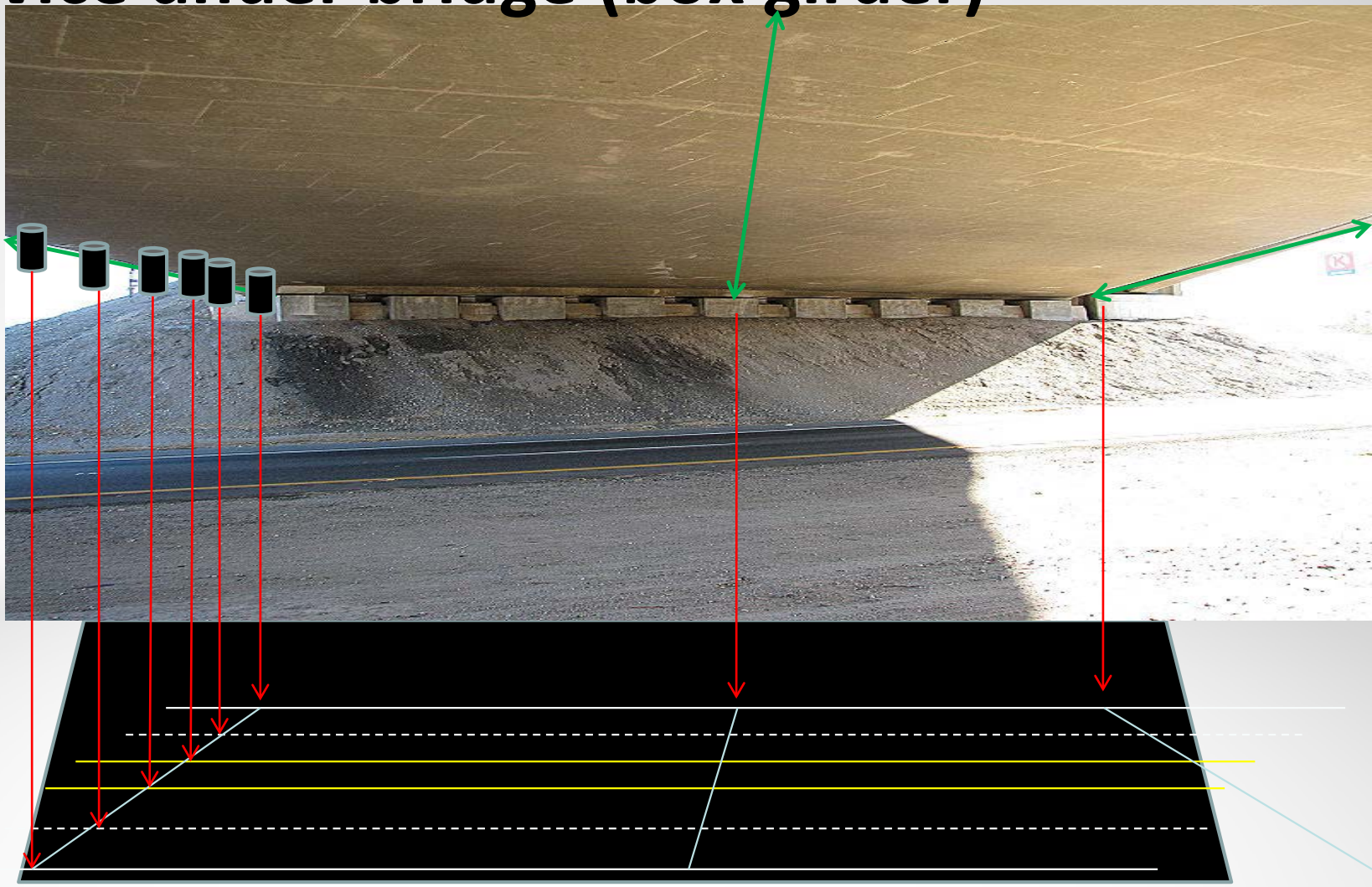


Need a travelling system for Mirror #2. Mirror #1 is set above shoulder far from striping Lining up of mirrors is crucial. Mirrors should be able to turn and have a black reflecting surface on the back

2a. Application of moving measuring device under bridge along steel girders



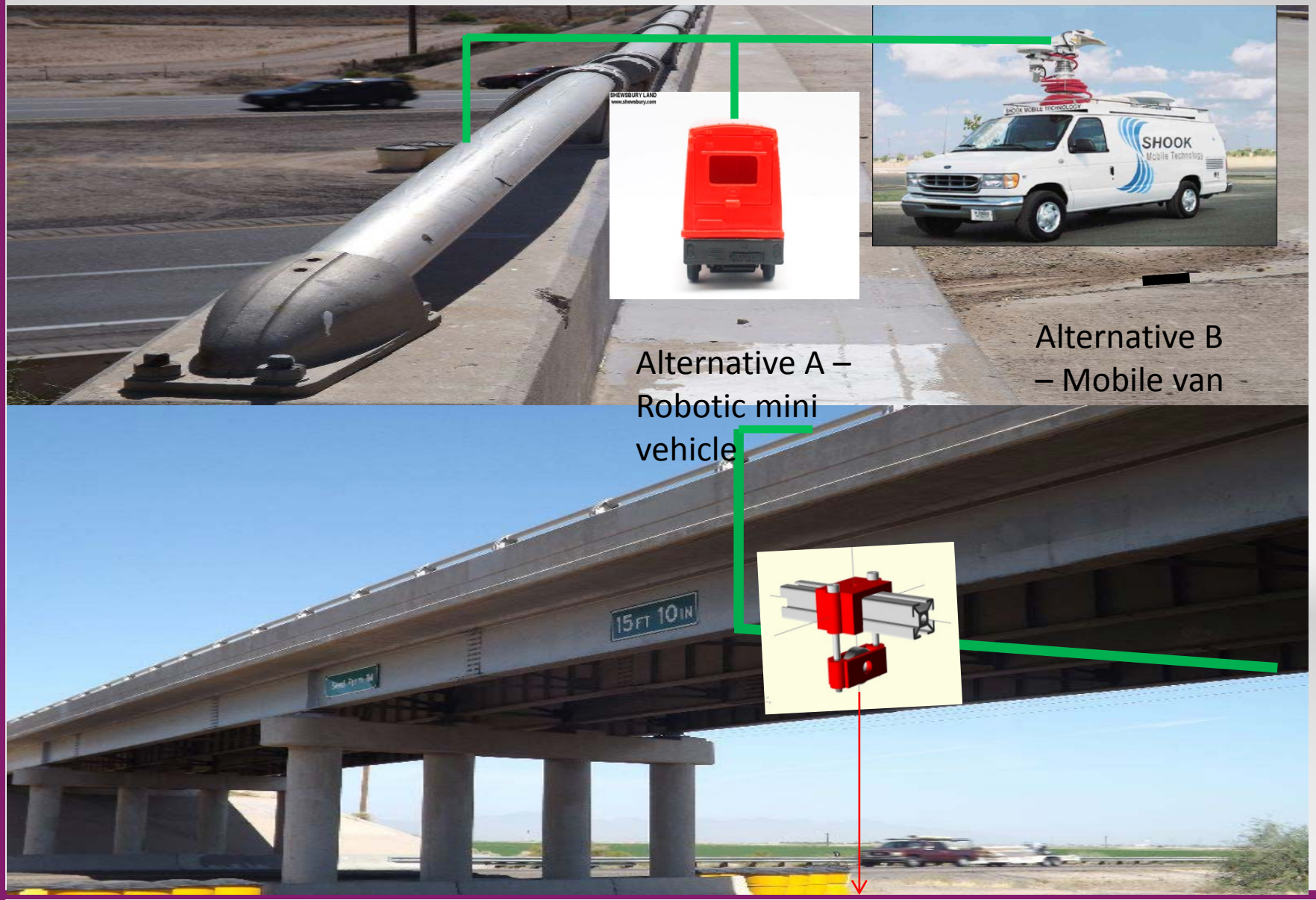
2b. Application of moving measuring device under bridge (box girder)



Potential Methods

1. use of vehicle with telescopic arm
2. use of robotic arm
3. Use of brackets, rods, rails and slides
4. Design and retrofits

1 & 2: Vehicle and robotic applications



Alternative A – Robotic mini vehicle

Alternative B – Mobile van

3. Use of brackets, rails & rods with slides

4. Design/retrofit considerations

- Openings in deck and / or superstructure for measurement
- Protected recess in road surface for measurement device movement
- Installing rail & brackets on girder webs over traffic lanes
- When financially feasible, install remote controlled laser measuring sensors to girders at desired points

VC measurement time calculator: Time is Money!

- List of highways that need the service
- List of bridges that have Public road underneath
- Cut-off level of vehicular traffic (e.g. ADT>500)
- VC measurement priority floor and ceiling (e.g. 14’-0”to 16’-3”)
- No. of traffic lanes
- No. of measurement rows (min. of 1 girder to max. of all girders)
- Unit VC measurement time in minutes (e.g. 1 minute)
- Unit recording time in minutes

ADOT

Calculated time for measurement of VC

Route	Min. MP	Max. MP		Hours
8-	0	175.65		20.60
10-	0	390.77		207.18
15-	0			0.00
17-	195.08	333.87		143.75
19-	0	61.9		20.29
40-	0	359.21		34.84
51-	0	11.03		7.95
60-	110.24	198.4		54.83
101L	0	60.54		53.69
143-	0	2.4		5.44
202L	0	13.21		26.22
210-	0			0.00
303L	105.2			0.00
Total Hours				574.79
Total Days				71.85
Total Years (220 Workdays per year)				0.33

Notes:

Min. ADTT Vehicles/da	measure time minutes	report time minutes	Measure points Slabs	Measure points Girders	Type of Service	14 VC Limit,ft	No. of 273	Time,Days 72	Total Miles 1196
1000	1	0	2	2	H	16.25	RUN		

If two lines for Slabs/Box Girders and Girders Chosen ==> ADOT

Input

Output

Input Cells

If an entry made,activates

Answers

Erase

Fill

Time keeper

6 : 1

It will be presented to ADOT in near future for potential use

Analysis of 1130 structures W/under record

ADT	Min. VC, feet	Max. VC, feet	# bridges	# of hours
1	1	100	1130	1952
100			1095	1904
500			1009	1848
1000			960	1800
5000			854	1696
10000			739	1576
15000			630	1448
1	14	16.25	342	528
100			296	504
500			245	480
1000			228	464
5000			179	416
10000			139	368
15000			119	336
1	1	16.25	360	544
100			305	512
500			252	480
1000			233	464
5000			183	416
10000			143	376
15000			121	344

1 year = 2080 hours

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Any Questions?