





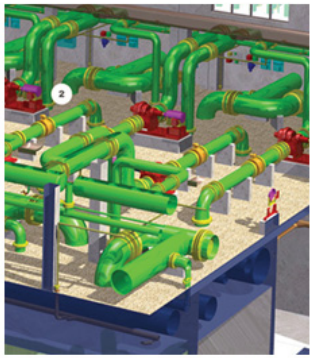

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Load Rating in a Production Environment

Ronald A. Love, PE

Western Bridge Engineers' Seminar

Bentley
Sustaining Infrastructure

Discussion Topics

- General overview of load rating
- Methods typically employed
- Load rating on production scale
- What is needed?
  - Data
  - Efficient processes
  - Organizational acceptance
- Examples
- Conclusions
- Benefits

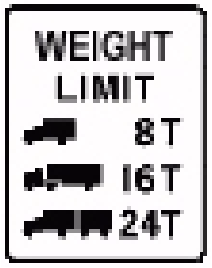
General Overview of Load Rating

- Determination of the safe load carrying capability of a bridge

********** LOAD RATING AND POSTING ********		CODE
(31) DESIGN LOAD	H-15 OR M-13.5	2
(63) OPERATING RATING METHOD	LOAD FACTOR	1
(64) OPERATING RATING	MS-14	25.2
(65) INVENTORY RATING METHOD	LOAD FACTOR	1
(66) INVENTORY RATING	MS-11	19.8
(70) BRIDGE POSTING	- POSTING REQUIRED	2
(41) STRUCTURE OPEN, POSTED OR CLOSED		P
DESCRIPTION - POSTED FOR LOAD		

1. For NBI reporting

2. For bridge weight posting



3. For OS/OW Permit support

What Is Load Rating?

- Determination of the safe load carrying capability of a bridge

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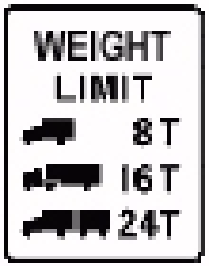


3. For OS/OW Permit support

Load Rating Tools and Methods

- Many methods used over the years
  - Hand calculations
  - Spreadsheets/MathCAD
  - Semi automation using envelope vehicle (compare vehicle to known rating of std vehicle)
  - Comprehensive computer programs and systems
- Typically methods utilize line girder method of analysis. More refined methods are on the horizon
- Specifications include ASR, LFR and LRFR

Load Rating Software

- Some commonly used original computer systems:
  - **BARS** (Bridge Analysis and Rating System): Control Data Corp. then AASHTO
  - **BRASS** (Bridge Analysis of Structural Systems): Wyoming DOT
  - **BAR7**: PennDOT
  - **Virtis**: AASHTO
  - **LARS** (Load Analysis and Rating System): Bentley
  - Others: **Merlin Dash**, **MDX**, home grown systems…

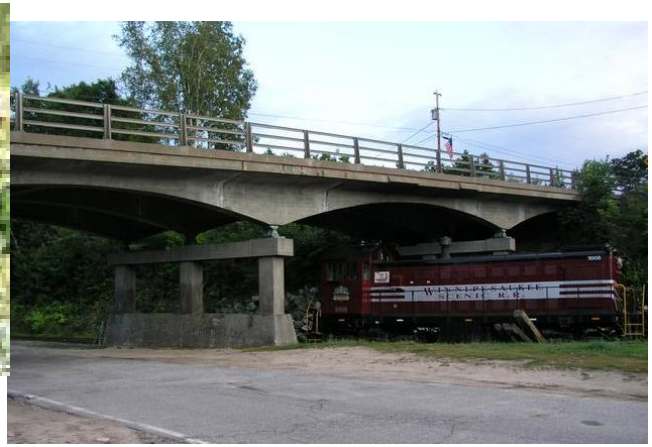
Load Rating on a Production Scale

- Requires processes that perform the functionality of the previously mentioned systems reliably and quickly.
- Maximize use of automation
- The result must be the same as if individual bridges were analyzed one at a time
- Requires data models of each bridge, or a majority of the bridges, in the state's highway network
- Focus (currently) is on routine bridge types

Bridge Types

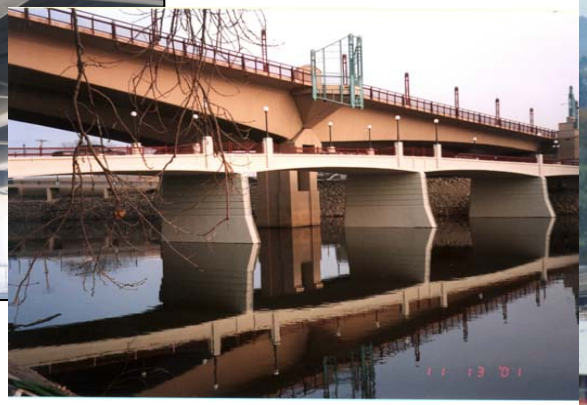
Pre-stressed Concrete

Timber



Reinforced Concrete Tee

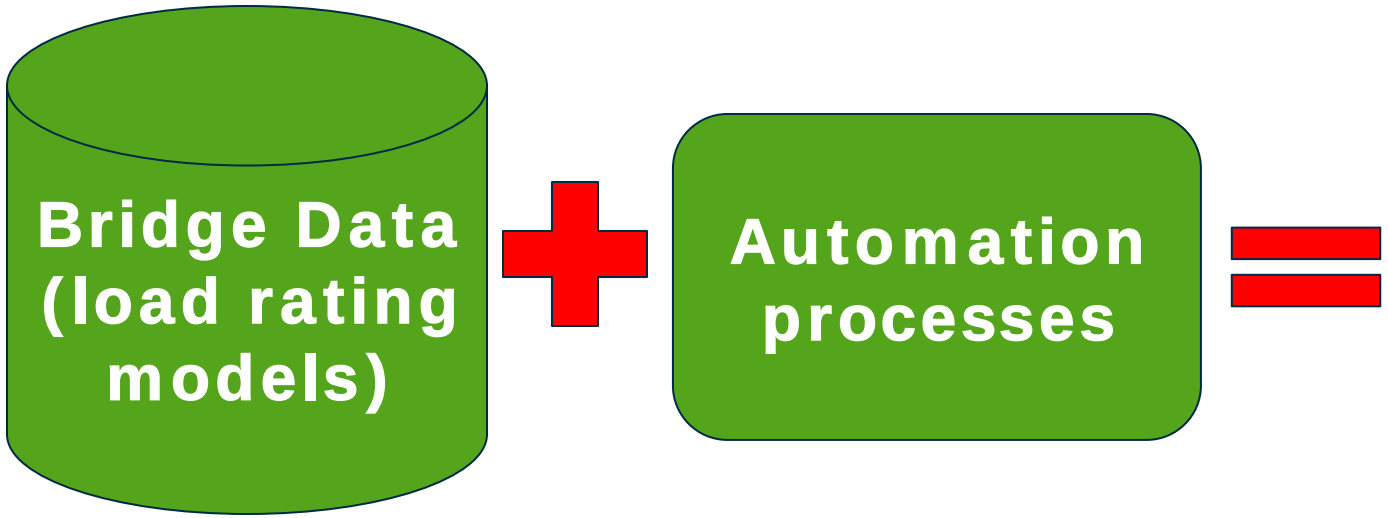
Composite Steel



Reinforced Concrete Slab

Trusses

Production Load Rating Solutions



Data

- Data is the key element for production load rating
- Need to support multiple data sources
  - Model efficiently in native system
  - Import from other sources
- Support as many bridge types as possible and add more…
- Primarily focused on common bridge types
- Scale to add more complex bridges in the future

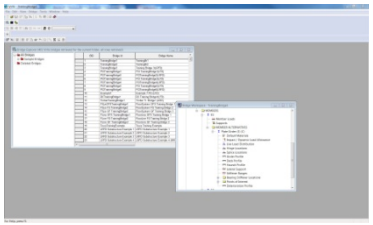
Example Bridge Data Sources

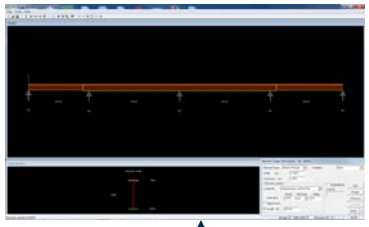
- **Model Bridges in Host System (LARS)**
  - Arkansas DOT (approx. 1400 bridges in one year on heavy haul routes)
  - Nebraska DOR (approx. 2200 bridges in one year using resources at NABRO (Univ. of Nebraska)
  - Illinois Tollway (approx. 200 bridges in 3 mos.)
- Import from other formats. i.e. LARS Connector **extraction of bridges directly from AASHTOWare Virtis**
- Import **AASHTOWare BARS** data directly. Thousands of bridges in this form still in use!
- Others as needed….

Processes

- Ability to handle the common bridge types
- Current with latest bridge specifications
- Accepted analytical methods
  - Live load distribution factors and influence lines for live load
  - Ability to verify results
- Use stand alone or as part of larger integrated process
- Examples will follow…

Combining Data and Processes





Virtis

BARS

Import

LARS

RouteRunner

SUPERLOAD

OW Permit Support

State-wide bridge rating

Posting

Push to BMS

Etc .....

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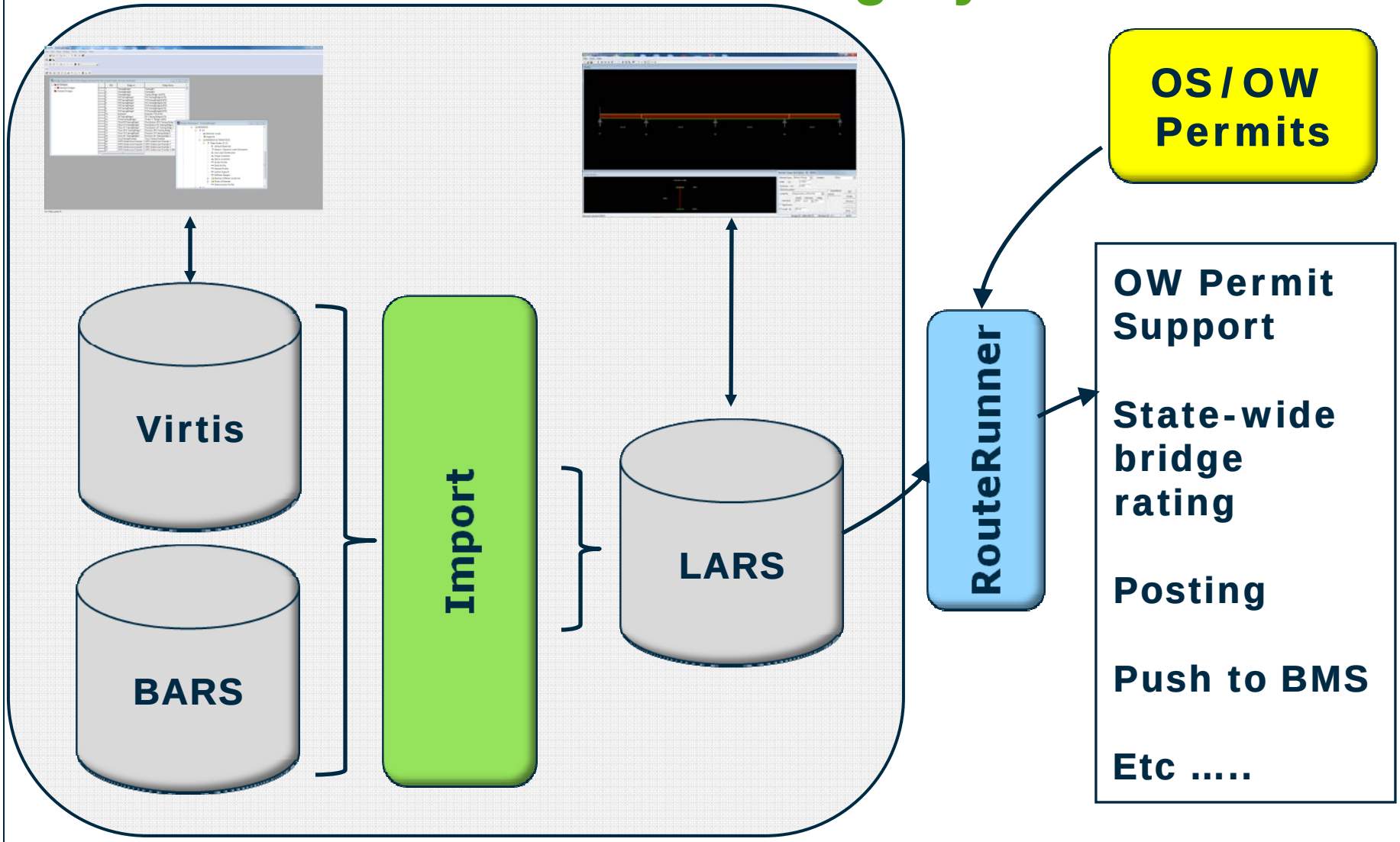
IDOT/MoDOT Load Rating System

- Using LARS Bridge, both Virtis and BARS data are converted and run by a single process
- The RouteRunner module is linked to the IDOT and MoDOT permit system via the “permit file”
- All bridges are automatically queued and the permit vehicle is applied
- Rating analysis takes place very quickly and results are easily viewed using Excel spreadsheets
- All results are retained for historical archiving
- The system is very easy to use

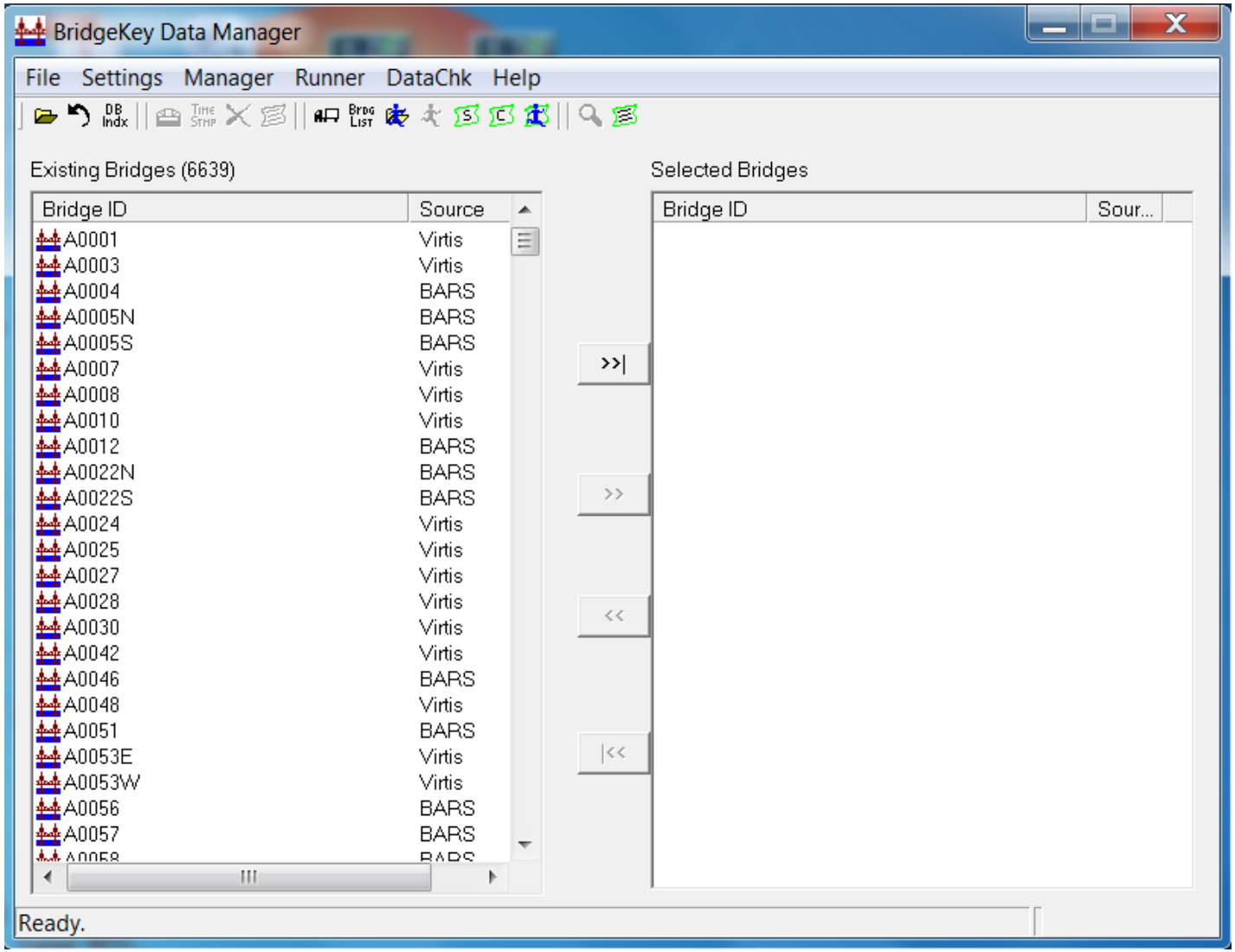
IDOT and MoDOT Goals

- Decrease time needed to turnaround permit requests
- Eliminate mainframe usage
- Leverage legacy data sources
- Fit well within their existing operations

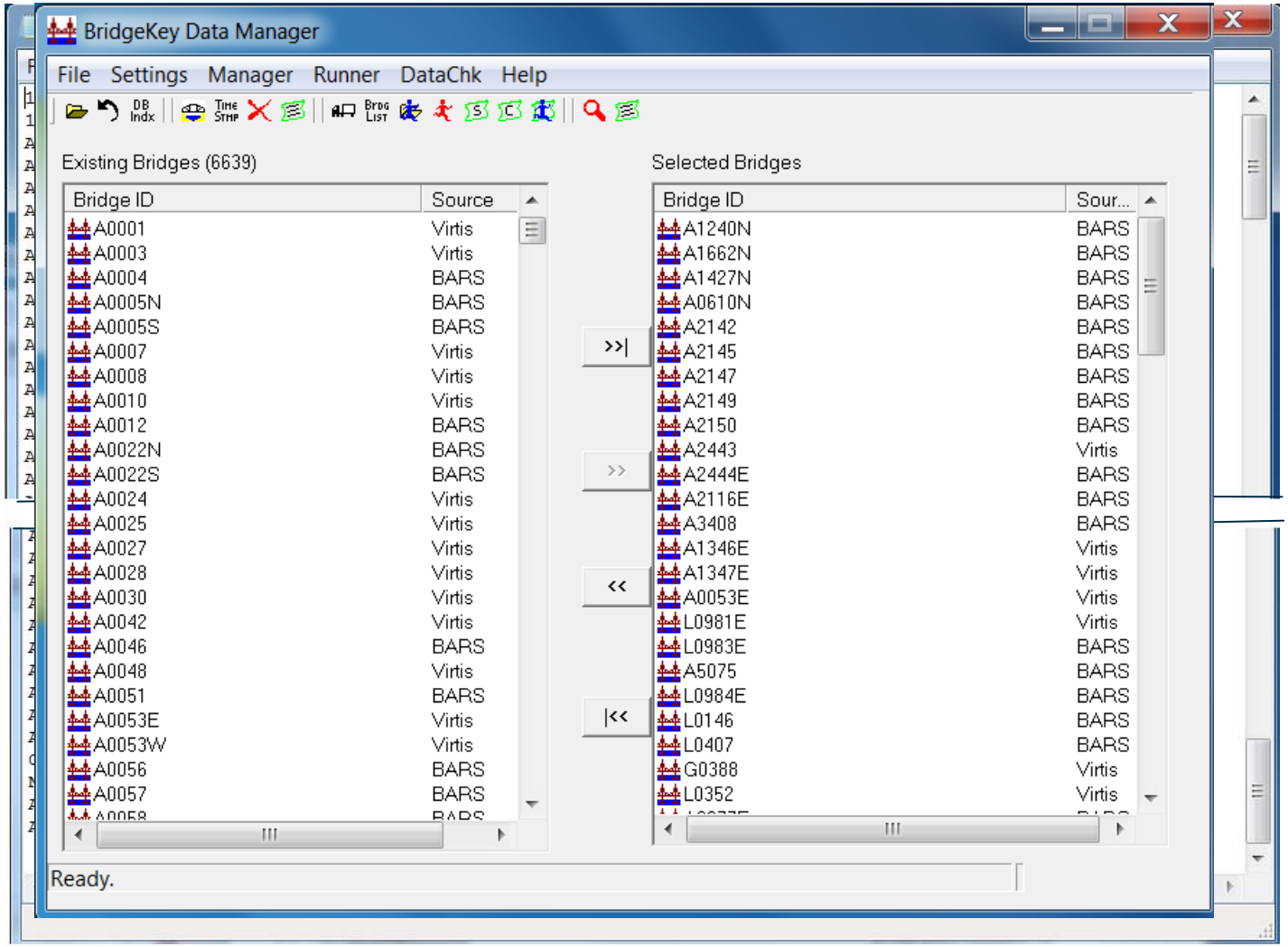
IDOT / MoDOT Load Rating System



LARS RouteRunner



LARS RouteRunner Permit File



LARS RouteRunner Results

	A	B	C	D	E	F	G	H	I	J	K
1	Structure I	Member ID	Critical CP	Material o	Impact fac	Rating Typ	Rating Truck	Rating Factor	Rating Factor No impact	Design Me	Rating Method
2	A1240N	G02	3	CPS	0.256	OPER.	1818	1.53	1.92	LFD	M
3	A1662N	G03	4	RC	0.3	OPER.	1818	1.17	1.53	LFD	M
4	A1427N	S04	4.5	CSC	0.3	OPER.	1818	0.84	1.09	LFD	M
5	A0610N	G04	5	CSC	0.185	OPER.	1818	0.96	1.14	LFD	V
6	A2142	S02	2.5	CSC	0.3	OPER.	1818	1.28	1.67	LFD	M
7	A2145	S01	4	RC	0.3	OPER.	1818	1.3	1.69	LFD	M
8	A2147	S01	1	RC	0.3	OPER.	1818	0.99	1.29	LFD	M
9	A2148	G03	4	CSC	0.3	OPER.	1818	0.97	1.26	LFD	V
10	A2150	S01	1.4	RC	0.3	OPER.	1818	1.86	2.42	LFD	M
11	A2443	S1	2.5	CSC	0.3	OPER.	1818	1.08	1.41	LFD	M
12	A2444E	S02	3.5	CSC	0.3	OPER.	1818	1.27	1.65	LFD	M
13	A2116E	G02	1.4	CSC	0.3	OPER.	1818	1.66	2.16	LFD	M
14	A3408	S01	2.5	RC	0.3	OPER.	1818	1.55	2.01	LFD	M
15	A1346E	G2	2.5	CSC	0.3	OPER.	1818	1.03	1.34	LFD	M
16	A1347E	G2	2.5	CSC	0.3	OPER.	1818	1.13	1.47	LFD	M
17	A0053E	G3	2.5	CSC	0.3	OPER.	1818	1.02	1.33	LFD	M
18	L0981E	G2	1.4	CSC	0.3	OPER.	1818	1.21	1.58	LFD	M
19	L0983E	S02	2	CSC	0.3	OPER.	1818	1.04	1.36	LFD	M
20	A5075	G0	2	CSC	0.253	OPER.	1818	1.01	1.37	LFD	M
21	L0984E	S01	2	RC	0.3	OPER.	1818	1.18	1.53	LFD	M
22	L0146	S03	2	CSC	0.3	OPER.	1818	1.08	1.4	LFD	M
23	L0407	S05	1.5	SS	0.3	OPER.	1818	1.27	1.65	LFD	M
24	L0352	G3	3	CSC	0.3	OPER.	1818	1.07	1.41	LFD	M
25	A0077E	S01	3	RC	0.3	OPER.	1818	1.08	1.41	LFD	M
26	A0208E	G02	2.5	CSC	0.3	OPER.	1818	0.93	1.21	LFD	M
27	A0110E	S01	3.6	RC	0.3	OPER.	1818	1.29	1.68	LFD	M
28	G0517	S11	2	SS	0.256	OPER.	1818	0.93	1.17	LFD	M
29	A0207	S02	1.4	SS	0.3	OPER.	1818	1.1	1.43	LFD	M

103 Bridges

4:09 Analysis Time

2.42 Seconds per bridge

Includes multiple lane/single lane with and without impact

Bentley

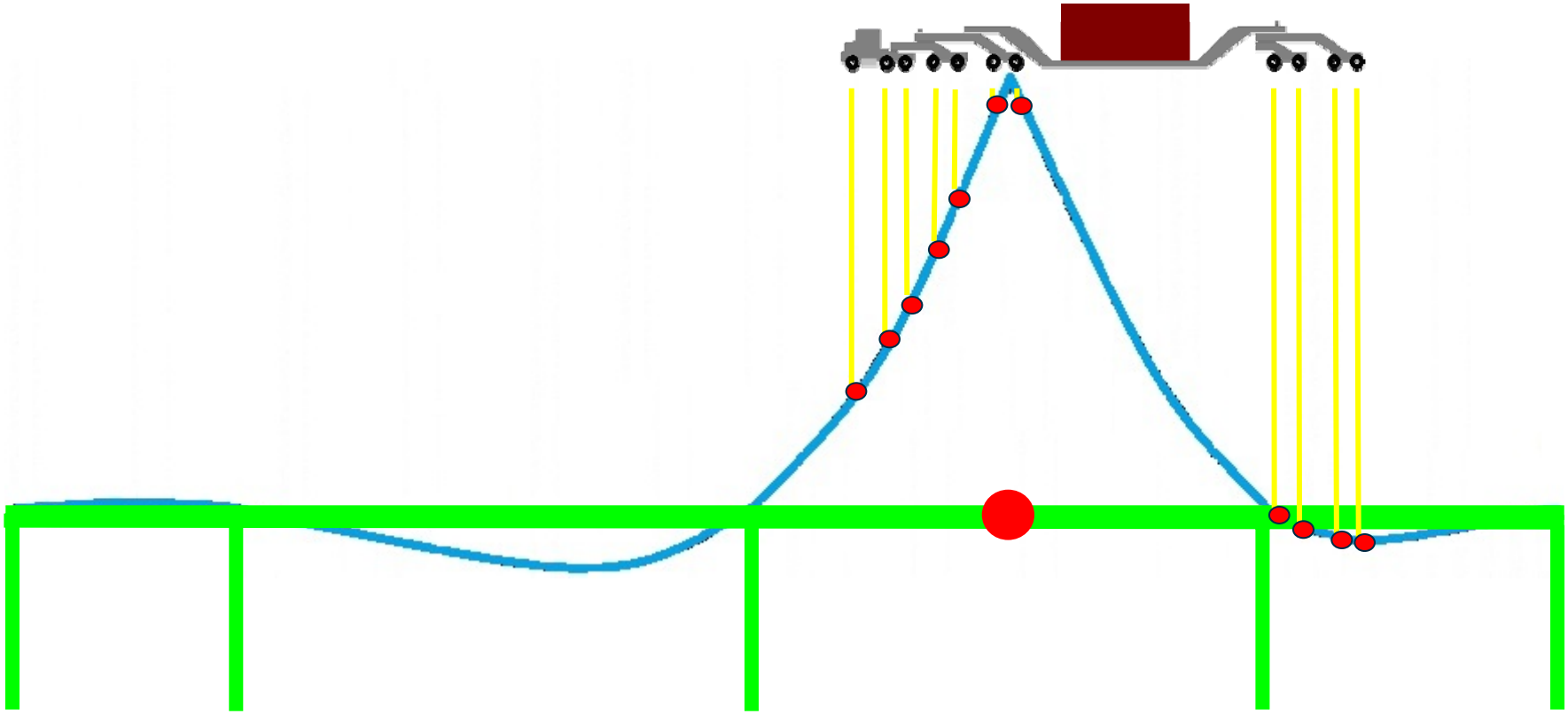
IDOT/MoDOT Load Rating System Benefits

- Eliminated the mainframe saving time and money
- Combined two valuable data sources into a single source
- Greatly reduced the time needed to turnaround permit bridge analysis requests
  - At MoDOT after one year of operation bridge study times went from **2.89 hrs. to 1.13** hrs per permit request
- Also use LARS to feed rating data to the states Transportation management System (TMS)
- Value in the ability to leverage legacy and new bridge data

The Automated Live Load Analysis - RR

- For every bridge along the route
- For every member in each bridge check every 1/10 point in each span
- Perform moment, shear and serviceability rating for the permit vehicle
- Determine critical rating
- Perform each rating considering full multiple lane full and low impact and single lane full and low impact

Ex: Bridge Live Load Analysis - Moment

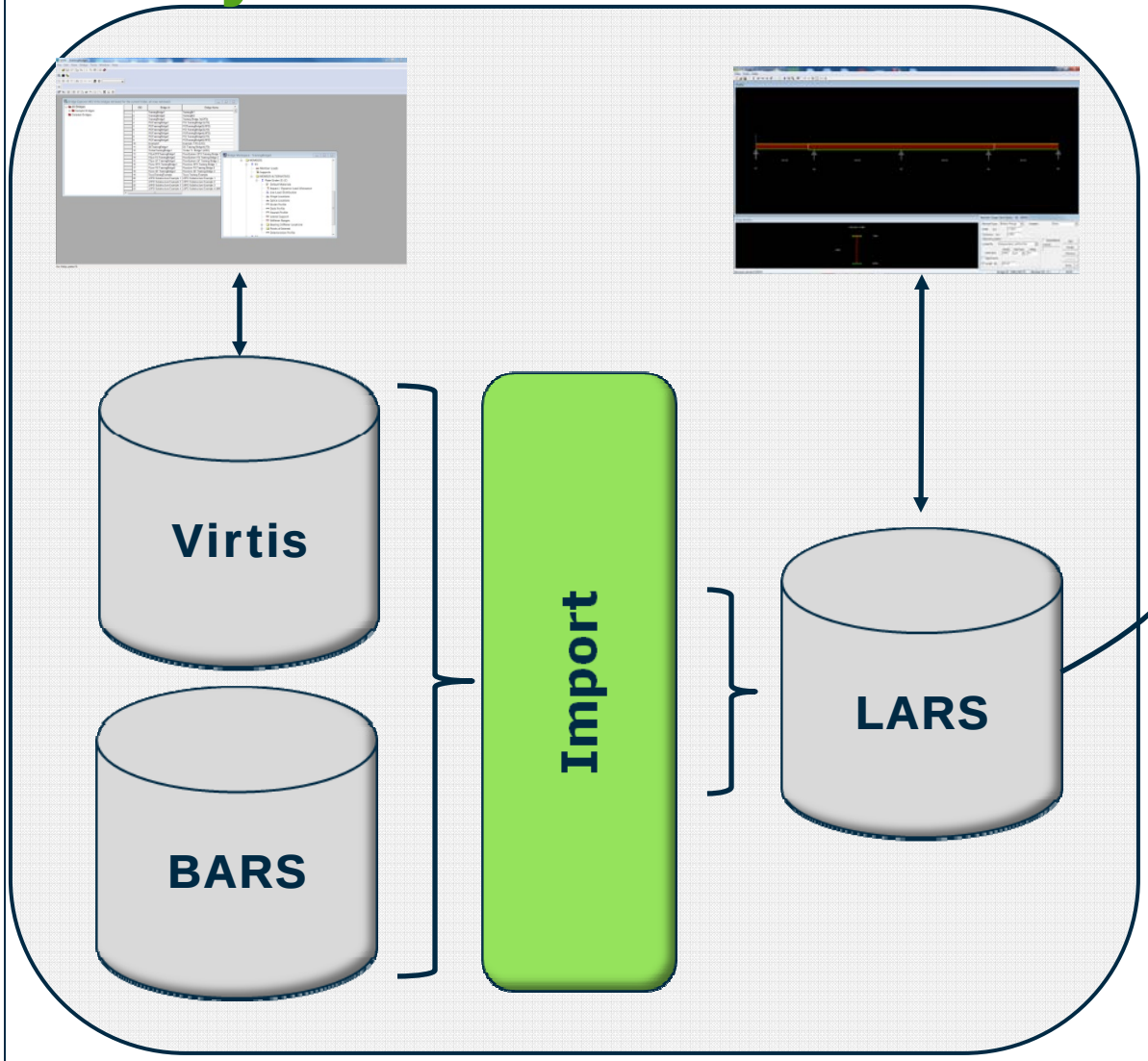


$$LLEffect = \left(\sum \left(AxleLoad \times ILOrd\right)\right) \times LLDF \times IMPACT$$

$$RatingFactor = Avail\_Cap\_DL / LLEffect$$

2 to 3 seconds per bridge

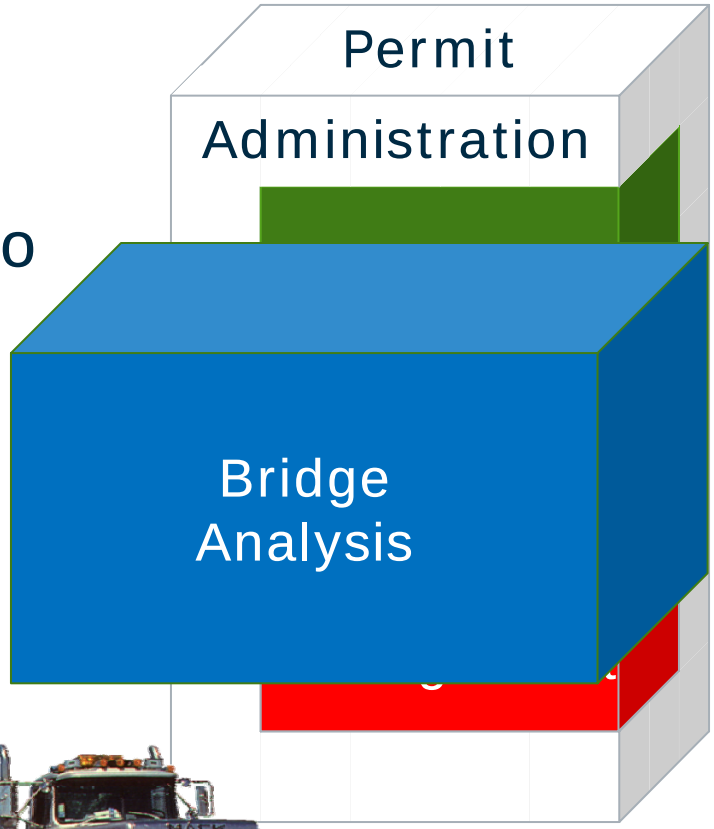
Fully Automated OS/OW Permitting

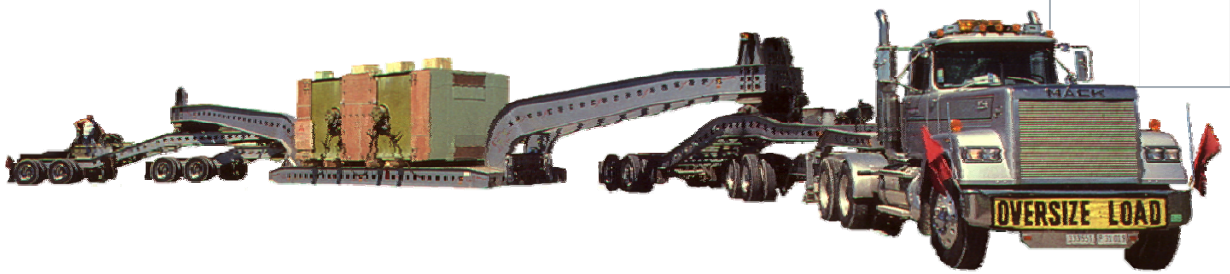


- OW Permit Support
- State-wide bridge rating
- Posting
- Push to BMS
- Etc .....

Fully Automated Routing & Permitting

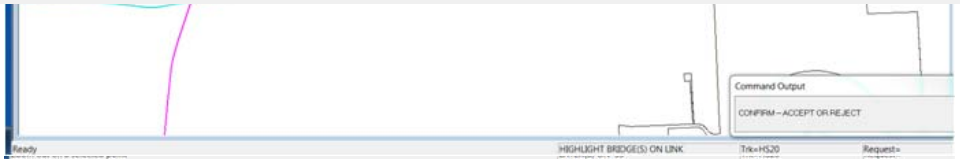
- Bridge analysis completely integrated with permits
- Delegation of responsibility to the automated system
- Permit self issuance – no manual intervention



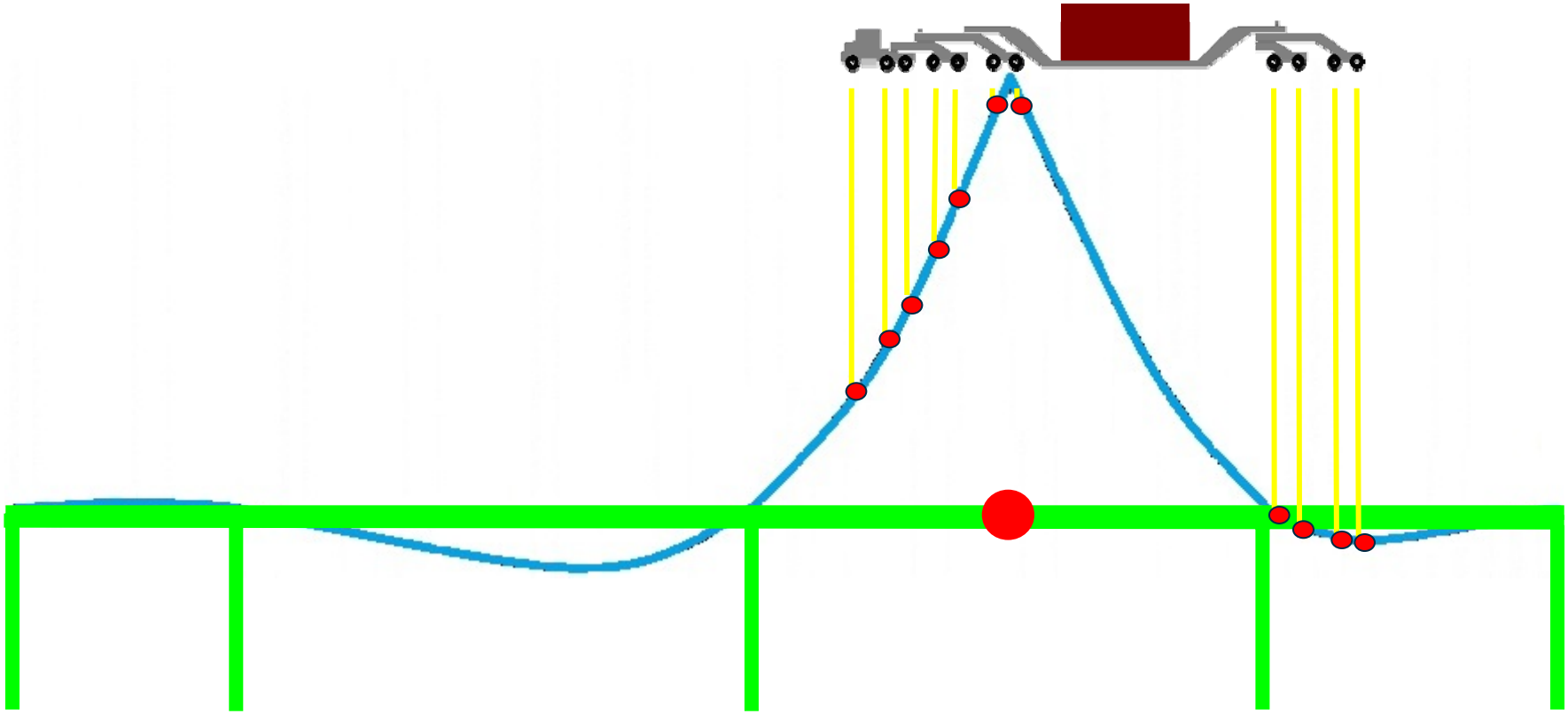


Routing and Bridge Analysis

STRUCTURE ID	--- MULTIPLE TRUCK LOADING ----- W/IMPACT RATING FACTOR	W/IMPACT SAFE LOAD (TONS)	LOW IMPACT RATING FACTOR	LOW IMPACT SAFE LOAD (TONS)	----- SINGLE TRUCK LOADING -------- W/IMPACT RATING FACTOR	W/IMPACT SAFE LOAD (TONS)	LOW IMPACT RATING FACTOR	LOW IMPACT SAFE LOAD (TONS)
S080_41204L	1.21	90.53	1.43	106.99	1.20	90.53	1.42	106.99
S080_41465L	1.52	113.99	1.75	130.90	1.93	145.08	2.22	166.60
S080_40977L	0.98	73.51	1.08	81.35	1.24	93.55	1.38	103.54
S080_40797L	0.91	68.49	1.01	75.80	1.16	87.17	1.28	96.47
S080_40872L	1.17	87.88	1.38	103.85	1.17	87.88	1.38	103.85
S080_40927L	1.19	89.36	1.41	105.60	1.19	89.36	1.40	105.60
S080_40577L	1.01	75.54	1.19	89.27	1.28	96.14	1.51	113.61
S080_40375L	1.53	114.84	1.70	127.60	1.94	146.16	2.16	162.40
S080_40414L	1.02	76.18	1.19	89.28	1.29	96.96	1.51	113.62
S080_40429L	0.87	65.10	1.03	76.94	1.10	82.86	1.30	97.92
S080_39904L	1.07	80.03	1.23	91.95	1.35	101.86	1.56	117.03



Ex: Bridge Live Load Analysis - Moment



$$LLEffect = \left(\sum \left(AxleLoad \times ILOrd\right)\right) \times LLDF \times IMPACT$$

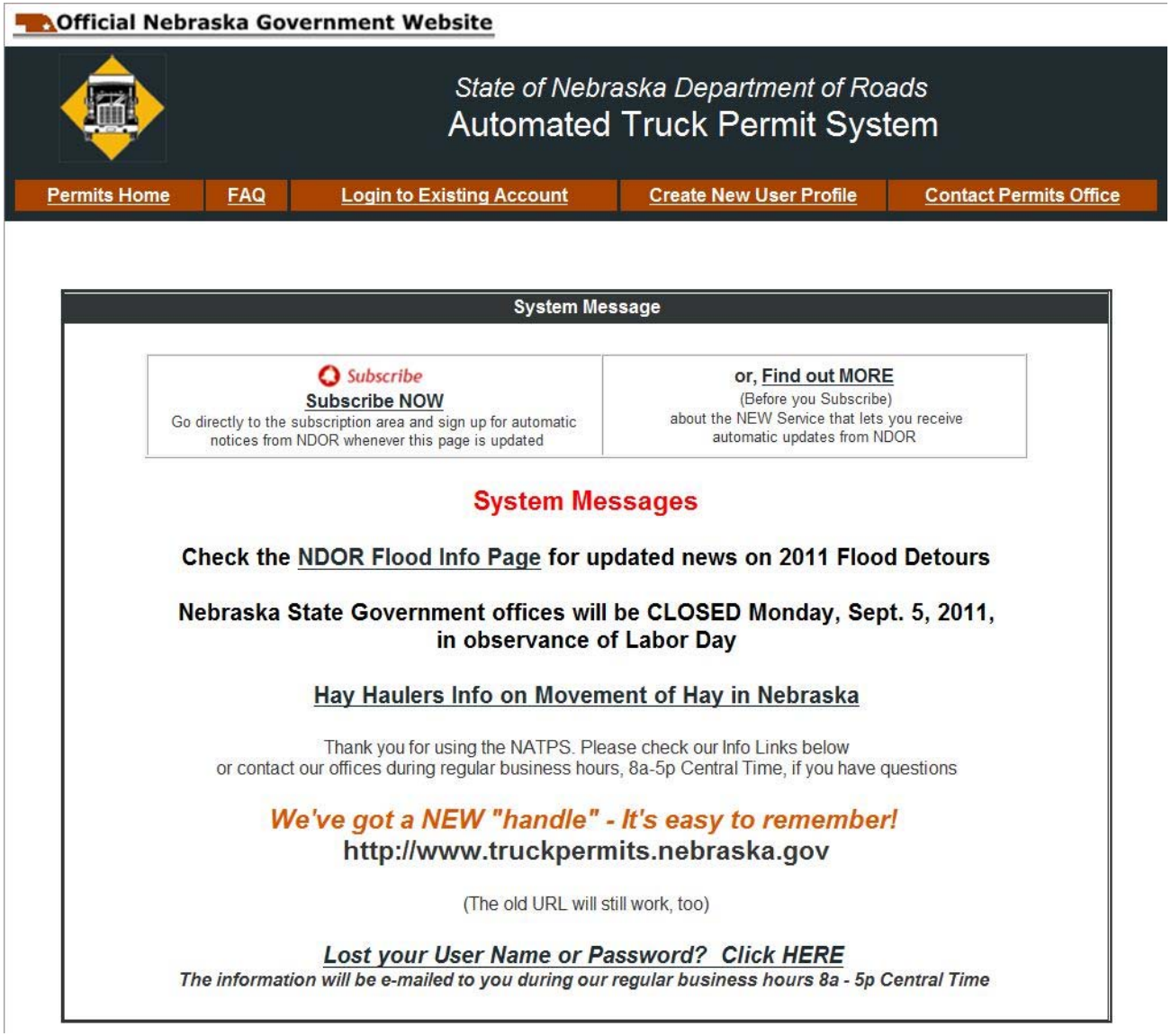
$$RatingFactor = Avail\_Cap\_DL / LLEffect$$

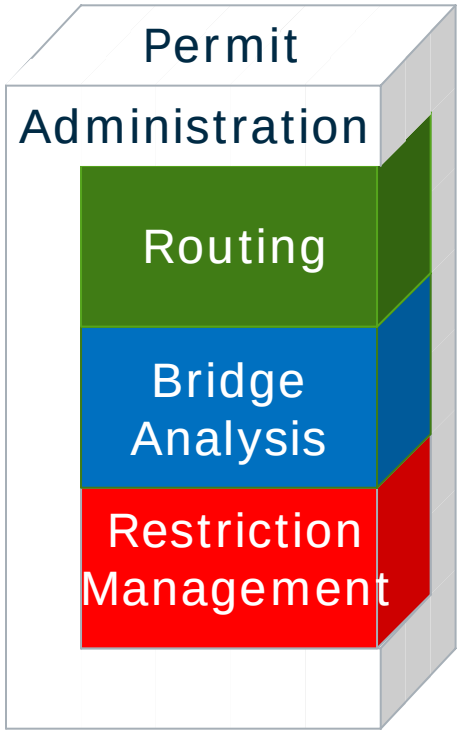
.02 seconds per bridge

Live Load Analysis Process Revisited…

- Every bridge along the route …
- For every member in each bridge check every 1/10 point in each span
- Perform moment, shear and serviceability rating for the permit vehicle
- Determine critical rating
- Perform each rating considering multiple lane full and low impact and single lane full and low impact
- Optionally generate restrictions based on the rating result

Demonstration: Automated Permitting





Summary

- NDOR processes approx. 107,000 permits a year
- Of this total, approximately 75 – 80% are self issued (i.e. no human intervention)
- Of the self issued permits, approx 33% or 26,300 are self issue permits that require weight analysis.
- At $25 per permit, this represents $658,000 in annual revenue for OW or OS/OW permits that require no manual intervention

In Conclusion

- Bridge analysis typically is the log jam in the OS/OW permit issuance process
- The quicker the bridges are analyzed (rated) the quicker the permit is issued
- Without load rating, automatic permit self issuance would be very difficult if not impossible to achieve
- A rigorous verification process is important
- Bridge analysis to support OS/OW permit analysis can be done semi-automated or fully automated with beneficial results.

Benefits

- Analyzing every bridge every time a permit is issued leaves nothing to chance and helps preserve infrastructure
- Automation facilitates/increases permit revenue
- Automation reduces labor needed to issue a permit
- Especially in the bridge group, routine permits are handled by the system freeing engineer time for detailed issues

Questions?

Thank You!