



Pavement Smoothness Specs for LTPP WIM Locations

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Long-Term Pavement Performance (LTPP) Study



20-year study whose goal is to provide data to explain

- How pavements perform
- Why they perform as they do



2,500 test sections throughout North America

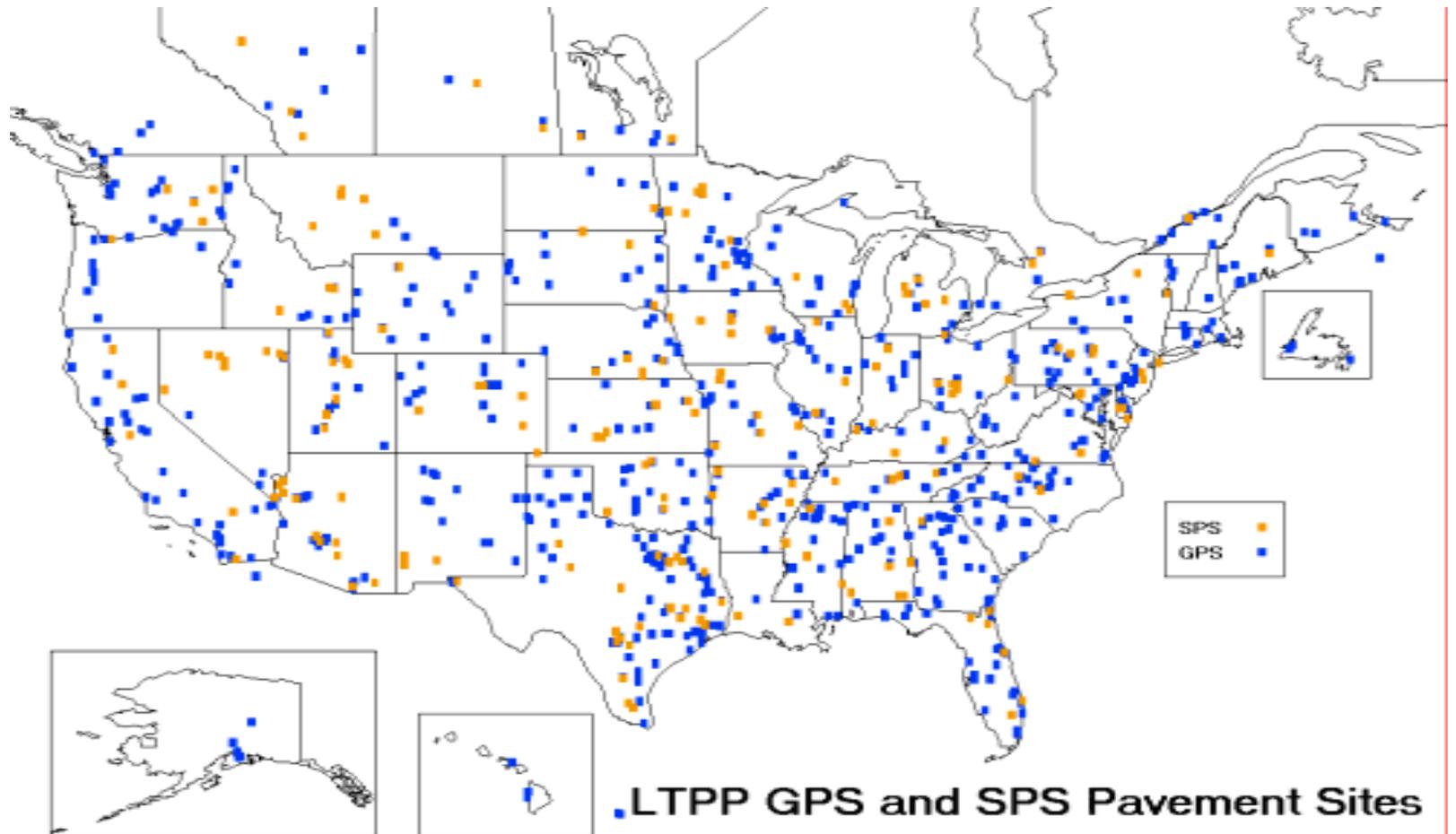


Data collected at each test section includes

- Inventory, materials, pavement performance monitoring, traffic, climatic, M&R



LTPP Test Section Locations





LTPP Traffic Data

-  **Loading data collected with WIM scales**
-  **Data accuracy affected by dynamic motion of trucks**
-  **Dynamic motion of trucks affected by pavement roughness**
 - Short wavelength: axle motion**
 - Long wavelength: body bounce**



LTPP Pavement Smoothness Specifications



Short and long wavelength specifications

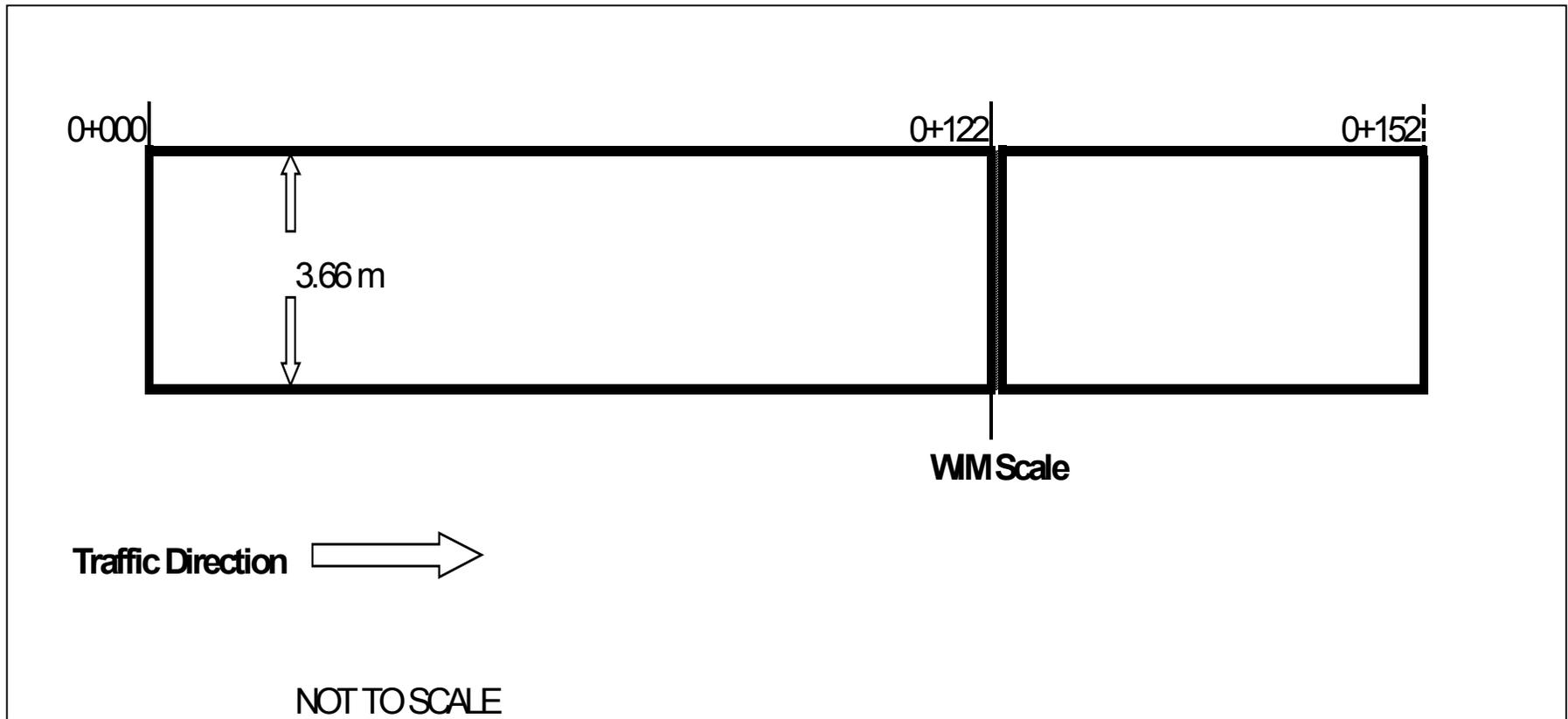


Test conditions

- **Acceptance of New WIM Sites**
- **Verification of Existing WIM Sites**
- **Annual Check of WIM Sites**



LTPP WIM SITE





Short Wavelength Specifications: Failure Criterion



Specifications similar to and based on ASTM E1318



Pavement must be maintained in such condition that 3-mm thick, 150-mm diameter circular plate cannot be passed beneath 3.66-m straightedge



WIM site considered to have failed even if single location fails

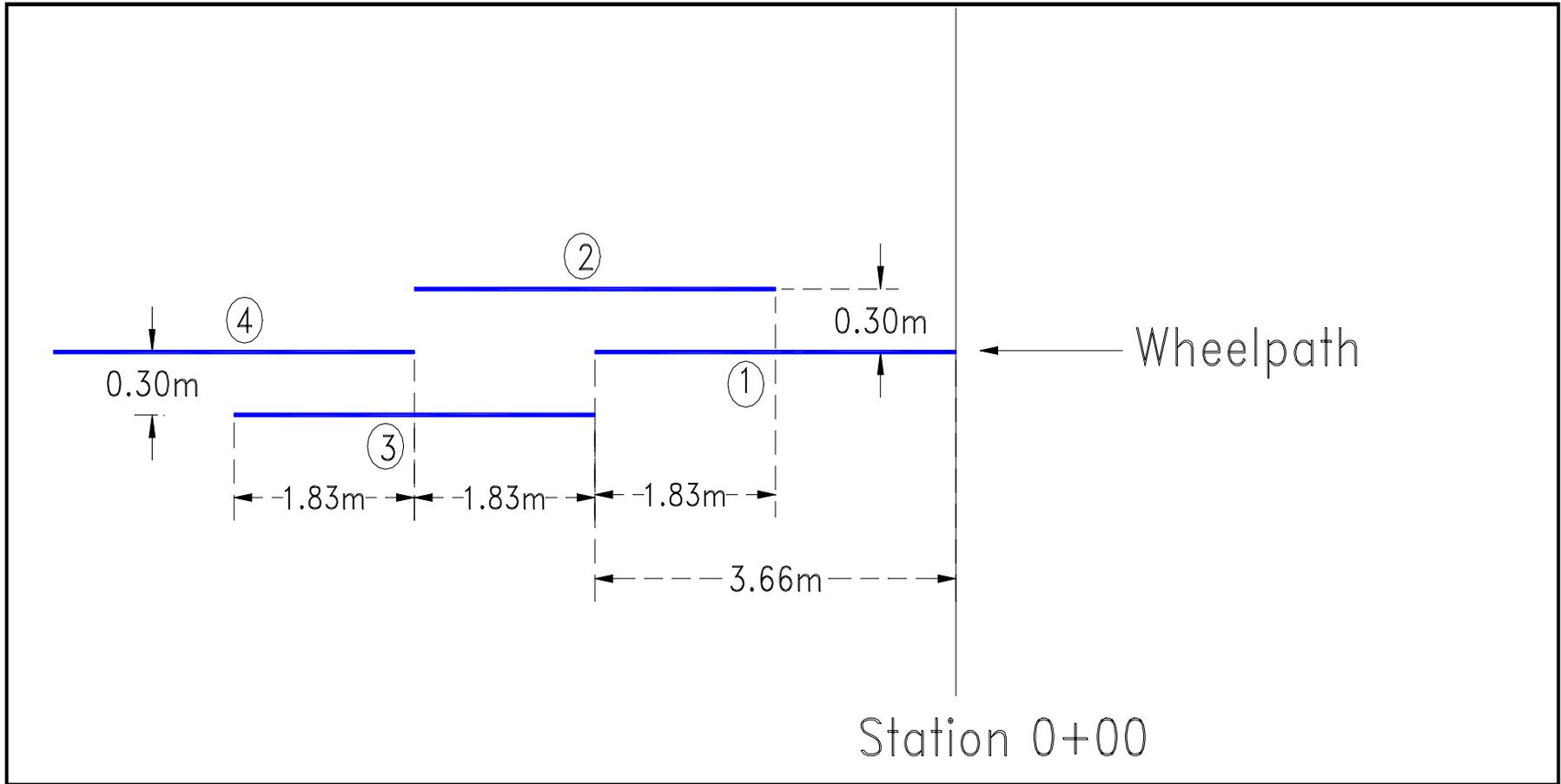


Short Wavelength Specifications: Acceptance of WIM Sites





Short Wavelength Specifications: Acceptance of WIM Sites





Short Wavelength Specifications: WIM Verification and Annual Checks

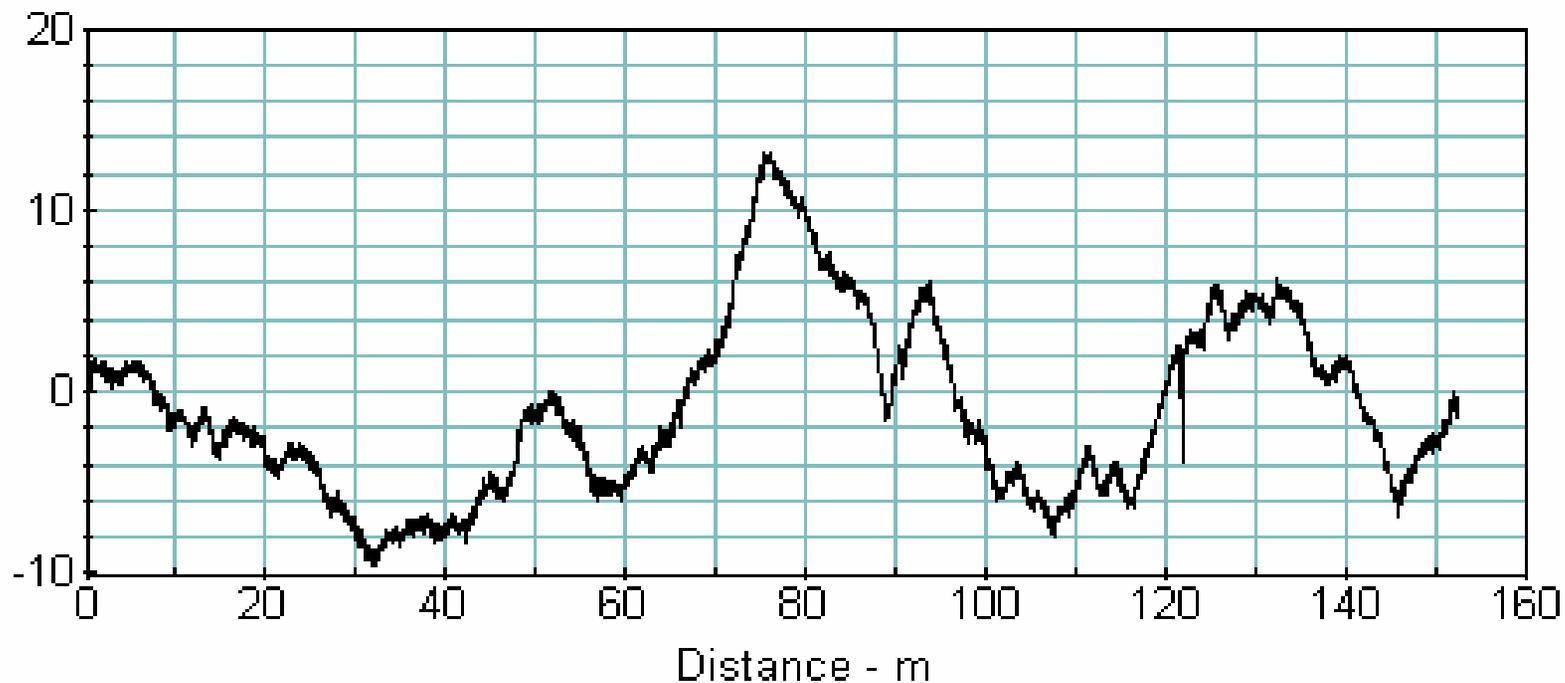




Short Wavelength Specifications: WIM Verification and Annual Checks

Profile Data: 100-m Cut-Off :

Left Elevation - mm





ASTM WIM System Tolerances

Case	Tolerance for 95% Probability of Conformity
Loaded Single Axle	+/- 20 percent
Loaded Tandem Axle	+/- 15 percent
Gross Vehicle Weights	+/- 10 percent



Dynamic Loading Error Specifications: Failure Criterion

-  **WIM site is considered to have failed if error estimated is higher than ASTM tolerances**
-  **Calculation procedure allows for identification of candidate locations for corrective action**



Dynamic Loading Error Specifications

- Standard for assessing surface profiles for 152-m length of WIM site**
 - **Criteria based on estimating probable dynamic tire forces generated by typical vehicles as they pass over WIM sensor**
- Limited to longitudinal profiles along each wheel path; no roll-plane vehicle motion**
- Normal statistical measures not appropriate because proximity of roughness to scale is important**



Dynamic Loading Error Specifications

-  **Index computed from profile data and compared to threshold values**
-  **Index and threshold values developed in large simulation study**
-  **Index statistically related to probability that 3S2 axle and gross weight are within ASTM tolerances**



Index Development

-  **Virtual fleet of 3S2 and properties of each vehicle assembled to estimate WIM sensor error due to roughness**
-  **Pitch plane models configured to read measured road profiles and to compute dynamic wheel load at each axle**
-  **Error at WIM sites estimated by simulating vehicle fleet over road profiles**



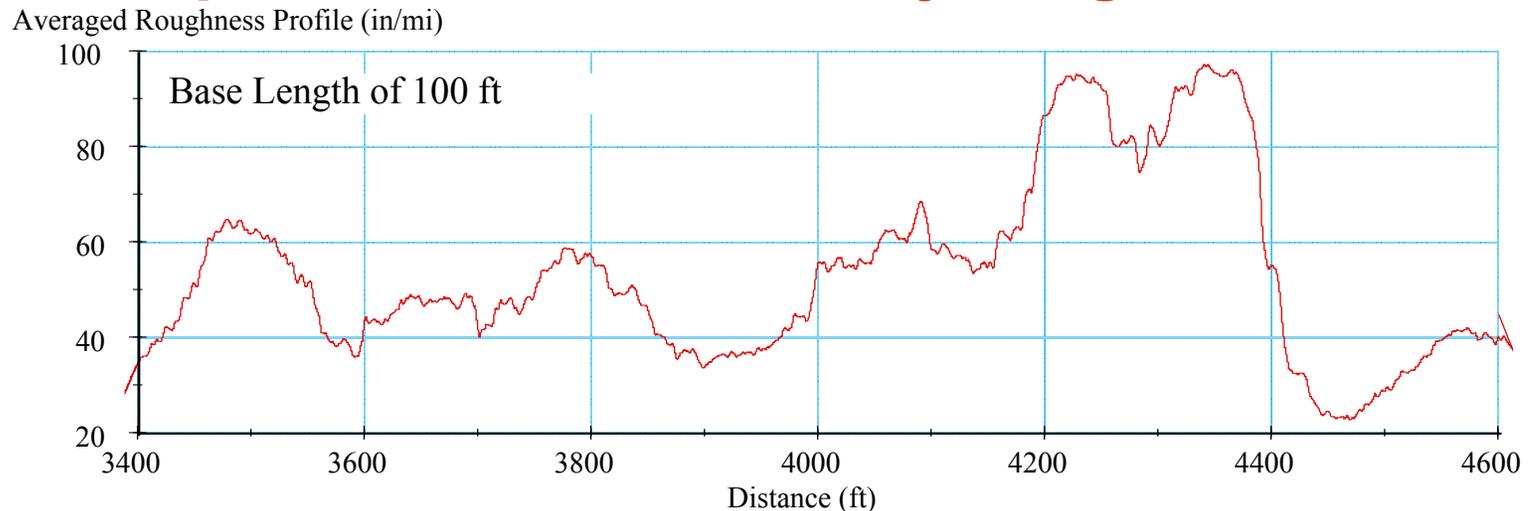
Index Development

-  **Potential indices evaluated through comparison of index value at each site to simulated WIM error level**
-  **Low standard error favored over high correlation coefficient**
-  **Several index types considered**
 - Will use Roughness Profile Index**



Roughness Profile Index

- Apply band-pass filter to profile
- Rectify resulting signal
- Apply moving average of short base-length
- Associate signal value at each point to expected error caused by roughness





Roughness Profile Index: Advantages

-  **Well established method of searching profile for rough segments**
-  **Provides continuous map of potential WIM scale error at every location along site**
-  **Short & long wavelength roughness can be pinpointed using distinct combinations of base-length and limit value**
-  **Could identify roughness that can and cannot be corrected**



Roughness Profile Index: Disadvantages

-  **Common profile measurement errors are hard to detect directly; so is curling**
-  **Maximum correlation to truck weighting error is not as high as an index that uses continuous spatial weighing instead of the roughness profile**
-  **Provides an estimate of absolute error only**



Index Development



Will use Roughness Profile Index method to estimate WIM error



Source code will be developed and incorporated into profiler software



Will leverage effort to eliminate ASTM short wavelength criteria; can be done using Roughness Profile Index method



Summary & Conclusions



Accurate traffic data is of paramount importance to LTPP program



Smoothness specifications developed for use at LTPP WIM sites

- **Short wavelength based on ASTM E1318**
- **Dynamic loading (short and long wavelength) based on results of large simulation study**



Specifications verified through various pilot studies; work is still on-going