FHWA Intelligent Compaction National Workshop Report No. 1, Atlanta, Georgia

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16. Abstract The FHWA has been leading a national effort to advance the Intelligent Compaction (IC) technology through a transportation pooled funded project, TPF-5(128), with twelve (12) States (DTFH61-07-C-00032) since 2008. Under this project, the Transtec Group has conducted seventeen (17) field IC demonstrations successfully to address material types that include granular soils, cohesive soils, stabilized base, and Hot Mix Asphalt (HMA) pavements. The FHWA Intelligent Compaction National Workshops are the continuing effort to fulfill the IC Road Maps developed under the TPF IC project in order to provide training to States and industry. The first workshop was conducted on December 13, 2011 in Atlanta, Georgia. This document is the report for the first workshop.		
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Background

The FHWA has been leading a national effort to advance the Intelligent Compaction (IC) technology through a transportation pooled funded project, TPF-5(128), with twelve (12) States (DTFH61-07-C-00032) since 2008. Under this project, the Transtec Group has conducted seventeen (17) field IC demonstrations successfully to address material types that include granular soils, cohesive soils, stabilized base, and Hot Mix Asphalt (HMA) pavements.

The FHWA/TPF project, led by the Transtec Group, also developed an IC Road Map that addresses the gaps and barriers for implementation that includes four major tracks: (1) Equipment and Technologies, (2) Data Management and Integration, (3) Specifications, and (4) Technology Transfer and Training (see Figure 1). An extensive knowledge base was built from those field demonstrations and is readily available to the public via the IC website (www.intelligentcompaction.com), also developed and maintained by the Transtec Group. The IC National Workshops under the FHWA TOPR No. 5 (DTFH61-10-D-00027) are intended to address key elements of the IC Road Map.

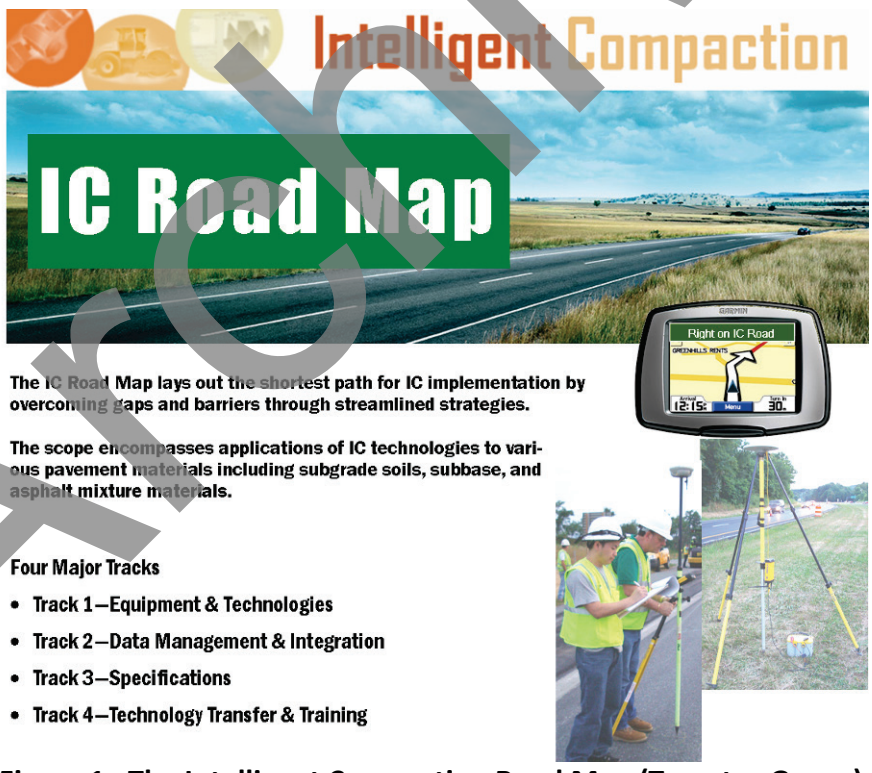

Figure 1. The Intelligent Compaction Road Map (Transtec Group)

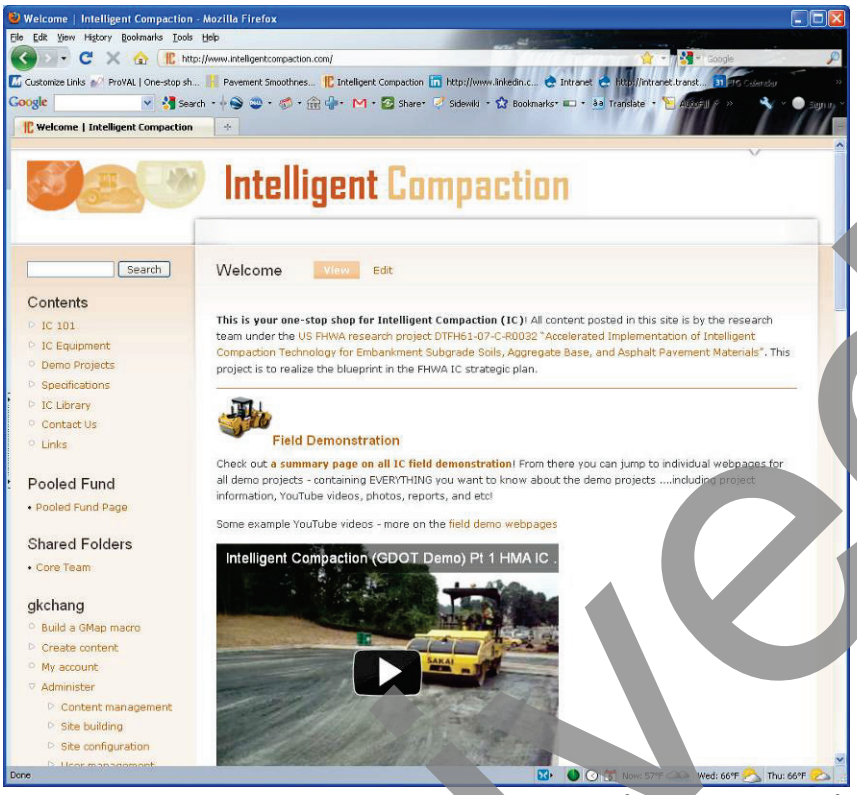

Figure 2. The Intelligent Compaction Website (Transtec Group)

Project Objectives

The objective of this task order is to provide non-personal support services to The Federal Highway Administration (FHWA) in facilitating, coordinating and documenting the Intelligent Compaction (IC) National Workshops in three (3) different regions of the country (e.g., Atlanta, GA, Salt Lake City, UT, and Minneapolis, MN). Specific activities will include: scheduling, organizing, and documenting the meetings, and coordinating and providing travel support to State Department of Transportation representatives and the non-Federal presenters who speak and participate in the workshops. Furthermore, the FHWA is offering professional development hours (PDH) hours to the attendees as part of the workshops and needs support in documenting and processing the requests.

The following includes the details about the first IC National Workshop in Atlanta, Georgia on December 13, 2011.

Workshop Event

The IC National Workshop No.1 was conducted in Atlanta, Georgia on December 13, 2011. The workshop facility was located at the Sheraton Gateway Hotel Atlanta Airport (1900 Sullivan Road, Atlanta, Georgia 30337).

Participants

This workshop was a one-day event attended by 58 participants. The sign in sheet is included in Appendix 1. The list of participants is in Table 1 and Table 2 (sorted by the last names). The distribution of participants is balanced from FHWA, State DOTs, contractors, vendors, and consultants/academic.

Table 1. List of Workshop Participants (1 of 2)

Last Name	First Name	Affiliation
Angerhofer	Paul	MOBA
Ardiff	Mike	Pittman Construction
Armstrong	Brett	Wire Grass Construction
Blight	Robert	NJDOT
Byrne	Michael	RIDOT
Casteel	Al	Georgia DOT
Cepko	Chris	PennDOT
Chang	George	Transtec Group
Connolly	Chris	Bomag America
Cooper	Steve	FHWA
Davis	Kendra	Georgia Asphalt Pavement Association
Duke	Matt	
Embacher	Rebecca	MnDOT
Etienne	Glenn	Construction Engineering Solutions
Evans	Richard	Wirtgen/HAMM
Felix	Tony	Reeves Construction Co.
Figueroa	Carlos Fernando	FHWA
Fluent	Chad	Volvo
Gallivan	Lee	FHWA
Geary	Georgene	Georgia DOT
Gee	Bryan	Tensar Co.
Hedderich	James	MOBA
Hines	Sheila	Georgia DOT
Horan	Robert	Asphalt Institute
Hourscht	Steven	Caterpillar
Jared	David	Georgia DOT
Jiang	Chenglong	Georgia Tech
Kline	Laura	King Asphalt
Korth	Kevin	FHWA
Kowalski	Tim	Wirtgen/HAMM
Kwon	Jayhyun	Tensar Co.

Table 2. List of Workshop Participants (2 of 2)

Last Name	First Name	Affiliation
Lockman	Mike	SC DOT
Mansell	Todd	Sakai America
Marcum	Bob	Volvo
Marshall	Wayne	Reeves Construction Co.
Michael	Larry	LLM Asphalt Consultant
Narsavage	Peter	Ohio DOT
Nieves	Antonio	FHWA
Painter	David	FHWA
Phillips	Jim	FHWA
Rawls	Dann	Caterpillar
Rilko	Wayne	U of Florida
Rish	Ian	Georgia DOT
Rutledge	Jennifer	Transtec Group
Scherocman	Jim	Jim Schrecoman Consultant
Schmidtgall	Scott	Caterpillar
Soriano	Ariel	City of Chattanooga, TN
Stewart	Charlie	Reeves Construction Co.
Upshaw	Patrick	FLDOT
Utsalo	Eugene	Georgia DOT
Vega-Meyer	Reinaldo	Tensar Co.
Wainaina	Njoroge	NCDOT
Wayne	Mark	Tensar Co.
Weaver	Chaz	Virginia DOT
Wood	Gary	Georgia DOT
Woods	Mark	TNDOT
Woolaver	Mark	Vermont DOT
Yager	Tony	Yager Materials

All attendees received hard copies of workshop materials in three-ring binders. The workbook content includes: agenda, contact information, presentation slides, top-ten questions and answers. The workbook content is included in Appendix 3.

Photos of several general sessions are shown below.




Agenda and Speakers

The objectives of this workshop are to:

- Familiarize attendees with fundamentals of intelligent compaction;
- Demonstrate the route to successful IC implementation; and
- Develop attendees into technology champions of IC for their organizations or companies.

The agenda is described in Table 3.

Table 3. Workshop Agenda

Time	Sessions		Length (min.)
08:30 am	1 - Introduction and Overview (Lee)		20
08:50 am	2 - Fundamentals of Intelligent Compaction (George)		40
09:30 am	3 - GPS for IC (George)		30
10:00 am	break		20
10:20 am	4A - IC for HMA (Bob)	4B - IC for Soils/Subbase (Rebecca)	40
11:00 am	5A - Panel Discussion on IC for Asphalt (Larry)	5B - Panel Discussion on IC for Soils/Subbase (George)	60
12:00 pm	Lunch break		60
01:00 pm	6A - IC-based QC and QA Specifications (Lee)	6B - IC-based QC and QA Specifications (George)	30
01:30 pm	7A – Panel Discussion on QC/QA HMA IC (Bob)	7B – Panel Discussion on QC/QA for Soils/Subbase IC (Rebecca)	60
02:30 pm	break		15
02:45 pm	8 - Demonstration of Veda - IC Data Management Program (Jennifer)		45
03:30 pm	9 - Panel Discussion (DOT's) on IC Implementation and Barriers-to-Overcome plus Q&As (Larry)		45
04:15 pm	10 - Conclusion and Workshop Evaluations (Lee)		15
04:30 pm	Adjourn		

The workshop speakers include:

- Victor (Lee) Gallivan, P.E., FHWA HIPT
- Dr. George Chang, P.E., Transtec Group
- Bob Horan, P.E., Asphalt Institute
- Larry Michael, LLM Asphalt Consultant
- Rebecca Embacher, Minnesota Department of Transportation
- Jennifer Rutledge, Transtec Group

Workshop Notes

There were many discussions during the workshop – one of the key elements that drew positive feedback from the participants. The following includes discussions and questions/answers during various workshop sessions.

HMA IC Breakout Sessions

IC is ready to implement now as a QC tool.

There is major innovation for rollers every 30 years, with vibratory rollers developed in the 1970's.

Why is the feedback system optional in IC definition? A: It is a useful tool but it is currently proprietary and vendor-specific (e.g., only Bomag and Amman/Case offer auto-feedback systems).

The gaps in the IC maps on the slide may be because vibratory is off (i.e., in static mode).

IC-MV is a generic term or umbrella for all IC measurement values.

It is very valuable for the roller operators to know the speed and frequencies shown on IC screens.

Stiffness is not density. (I.e., they are distinct properties. Stiffness is a mechanical property while density is a material proportional property.)

IC uses infrared temperature sensors to measure HMA surface temperatures, though internal temperatures would be better.

There are many shortcomings for conventional compaction and density measurements.

IC systems are very mature and easy-to-use by roller operators.

IC rollers can even be used to map rubblized concrete.

Wireless technologies would allow foremen to monitor the roller compaction in a trailer or from the office.

There are not a lot of best practices in construction.

Accelerometer is normally used in the lead drum of double-drum rollers due to data input needs.

IC-MV after the final pass should be used for payment decision.

IC is currently a QC tool but not a QA tool. The FHWA/TPF IC study focused on the existing technologies and field demonstration. An ongoing FHWA study is now geared to correlation between IC-MV with core densities.

IC can be a good QC tool to monitor density on pavement shoulders.

There are cost increases for IC as compared with conventional rollers. The retrofit system is attractive due to its lower cost. However, contractors may push back due to the additional cost related to IC.

IC is especially useful for nighttime paving to achieve consistent roller passes.

The cost increase due to IC may be outweighed by other benefits considering the life-cycle cost.

Surety costs are large expenses. IC is able to provide solid documentation that everything was done as it was supposed to be.

Is there a correlation between breakdown pass and final density? A: No, check the density behind each roller. Normally density is measured on breakdown because there is the most opportunity to change at the beginning of the process.

Recommendation to export/save data twice a day.

Georgia, Rhode Island, New Jersey, and Florida are considering implementing IC.

The supply and demand of IC equipment is a chicken and egg problem. Manufacturers may not be willing to provide additional equipment until interest increases, but agencies are hesitant to require IC if equipment is not readily available.

Vermont just put a sample spec in a project. Didn't change QC or any of the protocol, just added IC.

What are goals if correlations still need tested but specs are being implemented now? A: IC and density correlation would be nice but is not required. Even without that, there is success by knowing pass count, speed, coverage, uniformity, etc. "Satisfied with where this is, but not content."

Temperature is not a factor when calculating IC-MV. This is a gap because it is the primary HMA variable. For soils, moisture is an important factor.

Modified versus unmodified binders makes a difference. The test strip should be with the binder that will be used.

In the sample spec, it is the contractor's responsibility to supply equipment. This is basically the same responsibility of providing equipment now. Vendors present agreed that contractors could contact them or speak to a local dealer.

Is there a certification? A: No, but suppliers provide training and could recommend contractors. Could a formal certification program be beneficial?

For data analysis, Veda is encouraged. Roller manufacturers should be compatible with software (Veda or other).

IC users need training and initial on-site tech support from the supplier, followed by phone tech support. Suppliers need more than one week notice to provide equipment.

In addition to manufacturers, consultants (perhaps former vendor employees) could provide tech support. The generic spec currently requires technical assistance from a "roller representative," but this could say "competent technical support" instead. A certification program could help with this.

Familiarity with IC makes contractors more willing to try it. Speculated that contractors in Florida will want time, research projects, demos, etc. before implementing new technology.

Soils IC Breakout Sessions

How is IC data stored and transferred in order to be compatible with the FHWA protocol? A: IC data needs to contain essential headers and data elements. IC data also needs to be transferred from IC machines via media such as USB flash drives on a daily basis during construction operation. IC data need also be stored in vendor-specific formats and to be exported to text or ASCII formats that comply with the FHWA recommended IC data guidelines.

How to set up a base station? A: For physical onsite GPS base stations, one should follow manufacturers' recommendation for setup. The setup would require signals from 4 to 6 satellites for the initialization and 3 to 4 for the operation. Whenever there is interruption of the operations or signals, the base station needs to be re-initialized. Using a virtual GPS base station has no such restriction.

It may be difficult for contractors to buy-in to invest in IC under such a difficult economy.

The speed of wireless connection can be up to 1 GB/s (Ariel Sorland, Protecht Consulting) and the IC should take advantage of this data transmission technology.

IC-MV would need verification, calibration, and certification in the future. This is considered as the top priority by Mn/DOT.

How does Caterpillar verify their IC machines in the factory? A: Caterpillar tests the new IC machines on materials of known stiffness in order to verify the CMV (compaction meter value) and MDP (machine drive power) measurements.

IC is considered for quality control (QC) for now, as it is not ready for quality assurance (QA) yet.

Caterpillar stressed that IC is great for process control.

Can IC be used in roller compacted concrete (RCC)? A: By principal, IC can be used for RCC. GPS may be used in RCC already based on personal communication between George Chang and a company in Wisconsin.

Can IC be used as a part of the tamping bars of a paver? A: Volvo's pavers can track positions but not measure the responses of compacted materials. Volvo considers this as a good suggestion.

The Mn/DOT IC specs call for IC rollers of 22,000 lbs and above (i.e., 84" + wide drums). This would exclude smaller rollers that can be used, say, to compact trenches or utility works. Mn/DOT agreed that smaller IC rollers may be allowed in the future.

IC retrofit systems are valuable and attractive since they can be transferrable among machines.

On GPS precision of the IC system, the purpose is to make IC tracking and measurements repeatable.

Verification of IC-MV ranges is essential in order to differentiate materials of different stiffnesses. That is, IC-MV ranges need to be relatively wide instead of being narrow.

The following are current practices at Mn/DOT:

- Mn/DOT elects to use "weeks" as duration of pay items.
- Mn/DOT currently requires IC for top lifts but not for bottom fills.
- Mn/DOT uses Sonic test rolling in selected projects.
- Mn/DOT requires both the IC raw data files and exported (ASCII) files for submission.

Can IC be used for soil cement bases? A: Yes, IC was used for mapping soil cement bases on the FHWA/TPF IC demonstration project in MS.

Mapping the base line structures, especially milled asphalt surfaces, is difficult to measure in vibration mode while it may be potentially damaging to existing pavements or rollers. Making an extra pass on existing base using IC may potentially invalidate the requirements of base compaction from previous effort.

Is IC standardization in Europe more advanced? A: The IC standardization in Europe started earlier than that in the US. However, the progress for the European standardization has been slow. George Chang of the FHWA IC team has been communicating with Prof. Antonio Correia of the ISSMGE in this regard.

Coefficient of variation of compaction is essential to pavement performance. Since IC is still a young practice, using accelerated pavement testing (APT) to evaluate long term performance of IC is recommended.

Light weight deflectometers (LWD) are often considered as companion tests for soils IC. However, normalization of LWD measurements is needed due to various types of equipment from various manufacturers (e.g., deflection-based and load-cell-based).

The GPS accuracy may be affected by increased solar activities in 2012. Therefore, the GPS requirements may sometimes be beyond contractors' control.

IC training is a top priority. Caterpillar conducts their in-house training and certification. Can IC be used to reduce conventional testing? A: Yes, IC maps can be used to improve the selections of test locations (e.g., weak spots instead of random testing).

Uniformity is the key feature that can be achieved only by using the IC technologies.

Plenary Sessions

Are generic specifications online? A: Yes, on the Intelligent Compaction and FHWA websites.

Is the temperature sensor affected by water? A: Yes.

Is acceleration affected by the direction of equipment? A: No, it measures vertical acceleration.

Regarding the Veda software, it is suggested to change the y-axis of the histogram chart from Frequency (%) to Occurrence (%).

The barriers to overcome for implementing IC include:

- Being afraid to change
- Limited funding
- Limited supply for IC rollers
- Specifications to level the playing field

Why mandating contractors to use IC? A: To even the playing field. Contractors may lose bid if it is more expensive with IC. Why not using end-results based specs? A: Using end-results based specifications are often difficult and can be very expensive.

Solutions to overcome the above barriers for implementing IC include:

- Sound IC specifications
- Considering life-cycle cost (LCC) to justify the use of IC
- Getting lawyers and accountants involved (to explain liability, ROI)
- Changing the mindset (starting with younger generations)
- Managing risk
- Initial investment (actually would not level the playing field as it creates companies that have and others who have not)

The upcoming NJDOT IC project will consider IC for information only.

Mn/DOT has experienced difficulties for IC data management.

GDOT would like to allow contractors to try out IC.

Mn/DOT has conducted an HMA IC study on I-35 by retrofitting Trimble IC on all double-drum rollers. They also used PAVE-IR to record thermal bar data behind the pavers.

Mn/DOT indicated that IC vs. long-term performance is a priority study. Mn/DOT has been using MDP for mapping bases. (note that MDP is not accelerometer-based)

Mooney's IDEA study would be crucial to de-couple IC measurements to various pavement layers.

The No. 1 need is the IC training before project letting and pre-con meeting. Otherwise, bidding could be affected because experienced contractors would know what to expect but inexperienced may underbid. However, it should be considered whether the training cost should be paid by DOTs and incentives are needed for doing extra work on IC. IC vendors' technical support varies but is often poor.

The key for training is to change behaviors by telling them why. However, some objected that change is difficult and it would be better to start from the younger generation.

PAVE-IR is a system that includes multiple temperature sensors on a thermal bar that is normally installed at the leaving side of a paver. PAVE-IR provides 100% temperature map behind the pavers. GPS precision is still poor at 2 meters of precision but PAVE-IR comes with a distance encoder to compensate the location measurements. Currently, the States that decided to use Pave-IR include: AK, LA, MN, NJ, OH, RI, TX, WI, and WS.

Representatives from TN, GA, NJ, and MN expressed that their States would proceed with IC pilot projects in the future.

Workshop Feedback

There were 29 evaluation forms completed and submitted. The scanned version is included in Appendix B. The summary for the workshop evaluation is presented in Table 4.

Table 4. Summary of Workshop Evaluation

	E	G	F	P	VP
Meeting facilities	12*	15	1		1*
Preparation of the instructors	19	9			
Friendliness of the instructors	23	5			
Overall quality of the instructors	18	10			
Ability of the instructors to respond to questions/comments	19	9			
Ability of the instructors to lead the discussion	13	14	1		
Instructors' knowledge of the topics covered	20	8			
Usefulness of the materials/information for your needs	11	15	2		
Timeliness of the materials/information presented	14	14			
Quality of the technical presentation	14	13	1		
Workshop agenda	13	13	2		
Quality of folders, handouts, and other workshop materials	13	10	5		
Overall quality of the workshop	18	9	1		

*1 double response (included): E & VP for "cold room"

What did you like most about the workshop?

- Ability to meet people and interact, hear thoughts and direction
- General discussions
- Mix of government, consultants, contractors, and vendors
- The data analysis presentation
- Equipment suppliers present and onboard with support of technology
- Discussion and panel discussions
- The question-and-answer segments. Shows questions and concerns of those that are not as familiar with the systems but very interested in the technology
- Knowledgeable personnel
- Nice summary of IC
- Presentations and technology
- Input across the board from DOTs to manufacturers, to contractors, etc.
- Very informative and applicable to my work with state agency

- Very useful to have experts and manufacturers available for questions
- Excellent message received!
- Timeliness
- It was a very good way to distribute the information about the topic and dispel some myths
- Good balance of lectures and panel/open discussions (one of the best I've seen in a long time)
- Good discussions – good examples from real projects
- The free exchange of ideas and information
- Panel discussions
- How it was set up and splitting groups
- New technology applied to help on QC compaction, therefore better performance
- Excellent information and discussion

What do you feel could be improved about the workshop?

- Room temperature, slides in notebook, more about agency verification of contractor results calibration of equipment and qualifying of techs, example of QC & QA plans
- Broader acceptance of compaction measurement technologies – not only accelerometer based. Need to show practical ways how contractor can benefit because the benefits are there! Great training tool, helps identify process control issues, and much more. Drive this as forum spec
- More time in a relaxed atmosphere to exchange information/idea. Possibly a smoker, buffet, happy hour, etc. to create the atmosphere.
- More data
- Larger slides on handouts. Many captions are illegible
- Panel discussion at the end was poor: should have lead in points regarding impediments
- More examples using the Veda system
- Step-by-step real example of setting up test pad and determination of what stiffness value to select
- Clearer explanation of what IC will mean to DOTs and contractors over the next 5-10 years
- A few general details to explain each slide
- Provide copy of latest specification with binder
- Handouts should be in color to improve graph readability; moderators need to limit railroading by certain audience members
- More time on implementation spec!!!!!
- Need emphasis that must have buy-in by both agency and industry at executive level

- The handouts should be printed out in color instead of black and white
- Temperature control very cold; add tabs to binder? Put a microphone in the audience to help those in back hear better; room could have been lit better over the audience (screen was dimmed well)
- Location/facilities should be within walking distance to other restaurants/attractions in a nice area. Agenda should allow more time to "really talk and share info." - 2 day workshop with "ice breaker/open bar" works best!
- Would like to see bigger promotion (maybe pictures) of night paving (since industry seems to love this as part of night paving)
- More input from contractors actually using IC
- Hated that I could not be in 2 places at once – soils and asphalt sections / understand time limitations
- Discuss cost involved in adding equipment
- More animation and video. Booklet graphs need to be colored
- In-situ test if possible

Do you feel that all of the workshop objectives were met? If not, please explain which objectives were not satisfied.

Yes – 10
No – 0
Other:

- Supply a copy of the draft spec
- Most were met
- Yes, it was great information. Great job, looking forward to the next one.
- While it is nice to complete workshop in one day, it was difficult to choose between breakout sessions – and thus missing important information.
- Not yet. Technology's not there yet. Need automatic feedback loop to make vibratory adjustments ad needed on fly. Also, need missing link between rollers and "paver." Rollers are part of equation but the paver can also add to quality – good or bad.
- Yes – overall everyone should have left with a better understanding of IC
- Great job
- Yes – good information to bring to our state DOT – FDOT

Additional comments:

- Suggest you include generic requirements for state QA plan.
    - Best practices
    - Lessons learned (what did not work)
    - Emphasis – NOT USED FOR ACCEPTANCE OF WORK and ICMV is not density
- While the ICMV may not be a good acceptance measure and does not have a good correlation with density, proper data analysis (adding location info like distance from centerline or distance from edge of pavement) could be a good diagnostic tool for paving equipment.
- Give a better description of the further funding for taking this to the next level.
    - What does that consist of?
    - Projects and locations
- GPS accuracy check method is inaccurate and not required. Best would be to check at edge of drum. Horizontal tolerance should be 0.3 ft. Contractors should have previous experience with GPS equipment.
- Somehow, someway get the message to contractors to increase their attendance and input.
- What does it cost a contractor to purchase all for bidding a contract with IC – just ballpark.
- Logistics by Ms. Rutledge and Ms. Calisch were excellently done.
- Clearly emphasize up front that IC equipment does not yield direct percent compaction values such that time is not wasted from the audience trying to grasp the concept. Clearly explain that IC equipment yields IC-MVs and what they are
- Much more research is needed. Many variables still exist. Each manufacturer has their own system with their own units of measurement. That will be difficult for spec writing. The workshop stated that training would be required for foreman, operator, QC tech, DOT inspector, etc. That will be difficult due to lack of funding.
- Eventually could be an acceptance tool – I would not say 'never' – just that it is a long way off. Would be good to have a reference to research reports on the benefits of uniformity in construction to life of pavements – I know I have seen this presented at TRB.
- Excellent overview on IC – good stepping stone on bringing this technology to our state agency.
    - Add equipment POC's to website
    - Need POC's and project info with state DOTs, i.e. GADOT – 4 projects, locations, tonnage, equipment used, data summary

Workshop Improvements

The FHWA IC team concluded the following workshop improvements to be made in future IC workshops:

- Include IC specifications in workbooks
- Include attendance sheets
- Include attendees' agencies/companies on nametags
- Adjust times for sessions based on the actual time usage during the first workshop
- Add a cordless microphone for attendees to ask questions
- Improve the look-&-feel of workbooks
- Remove Mn/DOT Soils IC spec reviews in the soil IC presentation to avoid overlap with the generic FHWA specification
- Add contact information for both single-drum and double-drum IC roller suppliers
- Present the slogan "Consistency and Uniformity" through the IC workshop

Appendixes

The appendixes include:

- Appendix A – Roster Sign In Sheets
- Appendix B – Evaluation Forms
- Appendix C – Workshop Content