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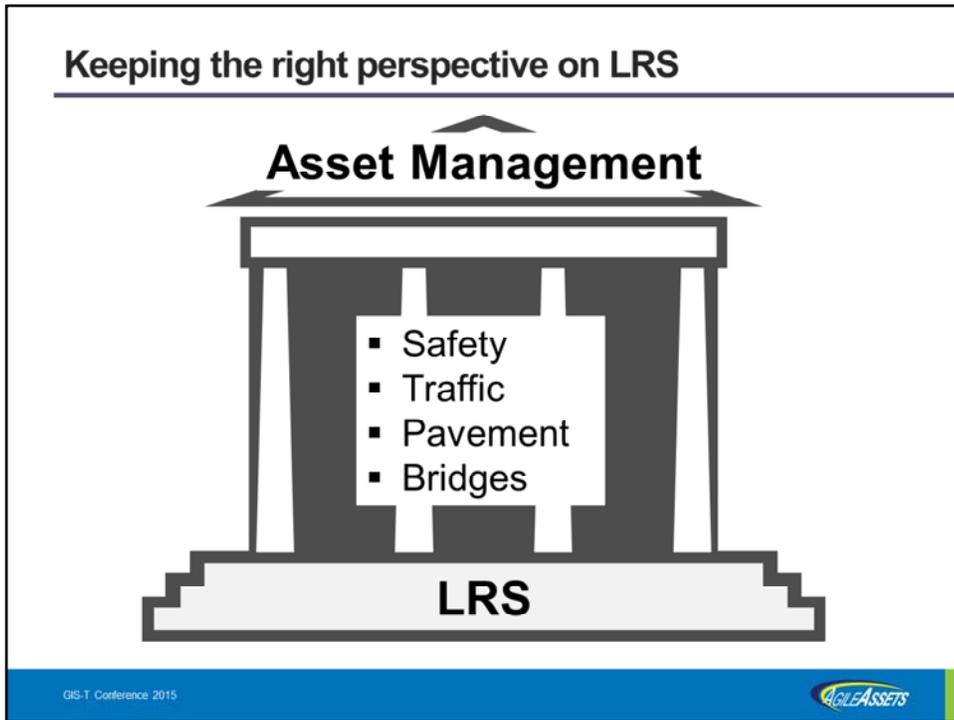
Turning an LRS into an Enterprise LRS

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April 13th, 2017



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Hi, I am Phil Hardy. I manage all of our LRS work at AgileAssets and my subject is making the most of your LRS implementation, specifically your Roads and Highways implementation.



But before we get started I want to make sure we are all thinking of LRS from the same perspective. LRS is important. It is the glue that is the commonality between almost all of a transportation agency's data. It is what allows us to find the hot spots that need attention, but...

It is only a foundation. It is not a goal in and of itself. It's importance is that it supports much of what the agency does, and a lot of that falls under the umbrella of asset management. That is, maintaining, and hopefully improving, the road network that helps to enable our citizens to lead productive lives.

Some advantages of using Roads and Highways

- Automatic downstream calibration
- Support for multiple LRMs
- Keeping temporal records of your road network
- Keeping an edit log of your LRS editing
- Etc.



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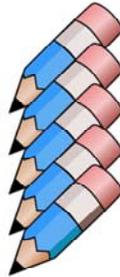
So, back to LRS and its most recent popular incarnation: Roads & Highways. This is a big step up from anything Esri has offered before in the transportation area. And it has some cool features. Automatic downstream calibration is a nice time saver. If you add a mile to the beginning of a route it can cascade those measure on down to the end of the route. Very cool. We can more easily support multiple LRMs. You can track changes to the network over time. It keeps a running edit log of who edited what and when. All of this is very cool...

But, by far, the biggest advantage is...

1 LRS Edit



Can automatically create
many local event edits



And many more
enterprise event edits



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But, by far the biggest advantage, at least in my eyes, is that when you make your LRS edits, let's take the mile we added to the start of a route a minute ago. When you make that LRS edit Roads & Highways automatically updates the locations of events within your geodatabase to reflect this edit. So your 1 LRS edit can trigger 10s or 100s of automatic edits without any extra effort on our part. That is very cool.

But, if that is where you stop you really haven't created an enterprise LRS. You haven't gotten your money's worth. Because regardless of whether the data resides in the geodatabase or not you have the ability to have Roads and Highways, keep your LRS and event locations up to date there too. Take NCDOT for example, they have about 13 million event records in their AgileAssets Asset Management System. So, by taking this last step, you can go from 10s and 100s of automatic edits to 1000s of automatic edits. And that is a very big deal.

How to get to the Enterprise LRS Level

- All systems with linearly-referenced data needs to get its LRS and event locations from R&H
- The popularity of R&H is getting most vendors on board with creating an interface
- In AgileAssets case we designed the interface with Esri and they created 2 web services for us:
 - Export Network – Provides the changes in the LRS Network
 - Relocate Events – Provides the changes to external events registered to R&H
- These web services are available to anybody to use



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So, how do you get to the Enterprise LRS level? Well, of course, to get to that level you have to have Roads and Highways manage the LRS and event locations everywhere you have linearly-referenced data.

So, how do you do that? Well, the first bit of good news is that the popularity of Roads & Highways has enticed most vendors to create an interface. And I am sure there are many ways that the interface can be done. In AgileAssets case Will Isley and I, and others, designed the interface together. On the Esri side of the interface what they built for us was 2 web services. The Export Network web service gives us the changes to the LRS since the last time we ran the interface. The Relocate Events web services updates our event locations to reflect all the LRS edits made since we last ran the interface. And, of course, these web services can be used by anybody to do the same thing.

One other use we found for the Relocate Events web service is to handle a case that I know Idaho and North Carolina have, and I am sure many others do as well. That is, at times, they copy out one of their condition tables and give it to crews who may spend the summer out in the field updating that data with current conditions. But during the time they are collecting data, the LRS might have changed several times. What Relocate Events allows us to do is to apply the effects of the LRS Edits to this data before we import it back in. This way it reflects the most up-to-date LRS.

Lessons Learned

1. Use right LRS Interface approach
 - Make sure your customers can choose when to update
2. Edit the LRS with Events in mind
 - Single-source LRS is a double-edged sword
3. QC your LRS like everybody is depending on you
 - Don't forget vertex measures when doing QC
 - Versioning makes life easier



So now I'm turning to another topic. What are the lessons learned from doing an interface to Roads and Highways. These are the areas I am going to cover next.

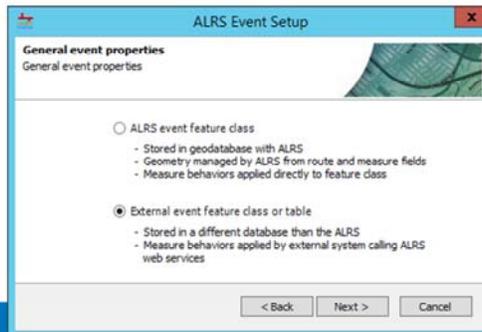


First lesson, use the right approach.

LRS Interface Approaches

Internal or External events?

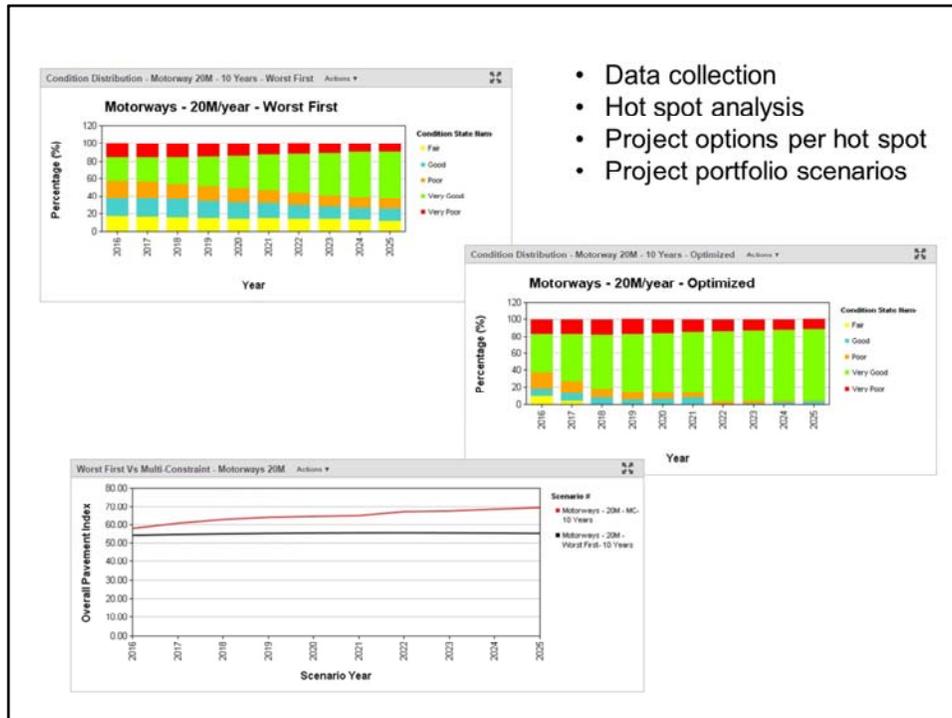
- Internal Events are updated directly by Roads and Highways and updates are automatic
- External Events are updated by Roads and Highways web services but allow the Event owner control over when updates take place
 - AgileAssets users strongly favor having control of update timing



I am sure there are many ways to create an interface, but one key decision is whether to use what Roads and Highways calls Internal events or External events. Internal events are those within the same geodatabase as Roads and Highways. External events are event data stored elsewhere but made available to Roads and Highways.

Besides data locations the key difference between these 2 approaches is who has control over when the data gets updated by the LRS. The timing for updating Internal events is under the control of the LRS editors. The timing for updating External events is under the control of the event data owners.

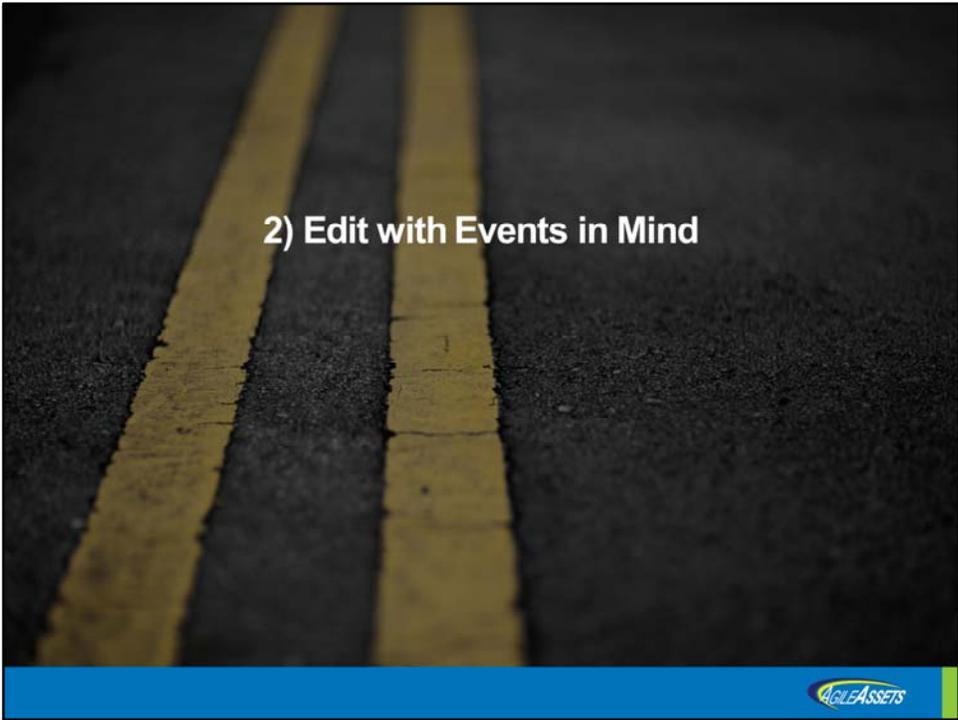
Now, I am an LRS guy, so my first inclination is to have the LRS editors control the timing. But from conversations with my customers that use our system they have come down strongly on the side of the event owners having control over this timing. And I have come to understand why...



- Data collection
- Hot spot analysis
- Project options per hot spot
- Project portfolio scenarios

In asset management, regardless of whether it is pavement, signage, safety, bridges, or whatever, the steps are pretty similar. I am showing a pavement example here. First you collect condition data. Using the software you find the hot spots that need attention. The software then comes up with options for each hot spot of different treatments that have different levels of benefit and different levels of cost. Option 1 may bring up to a certain level of service and have a certain cost. Option 2 may bring it to a higher level of service but have a higher cost, etc. After this the software helps you pick the combination of projects and the timing of those projects based on various criteria. If you use the worst first method you will get one set of projects and you can see its effects over time. If you optimize based on some other criteria you may get other results and you can see its effects over time.

The point I am making here is that there is a rigorous process going on and different options are being weighed against each other. While in the middle of this process our customers want to make sure that all the options are based on the same base data. So they want to have control over when that data is updated. That is why, at least for our customers, the ability to control this timing was very important. So that is the first lesson learned.

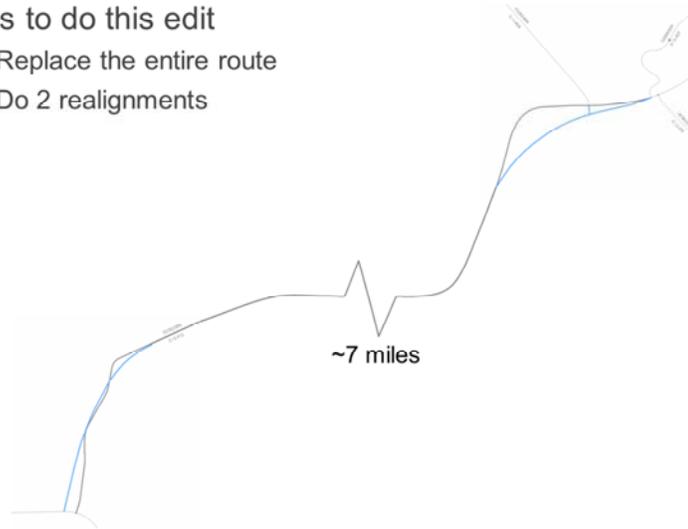


Next up, edit with the Events in mind

LRS Editing with Assets in Mind

2 ways to do this edit

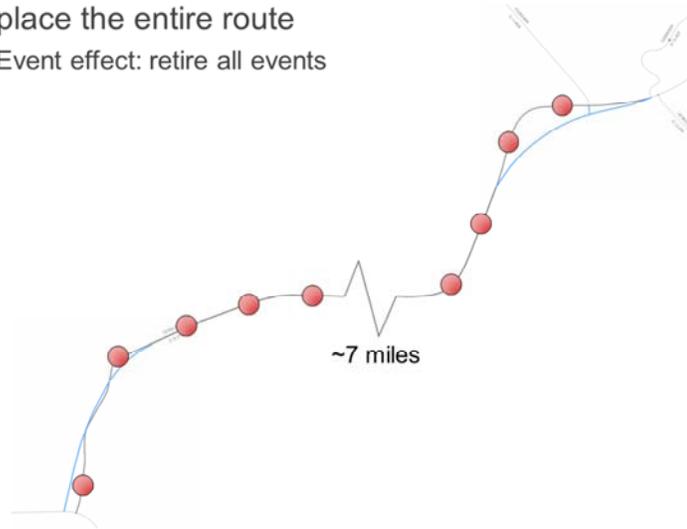
- Replace the entire route
- Do 2 realignments



I know Tim Sheldon did a nice analysis a while back with Roads & Highways showing how 2 different ways of doing the exact same edit could have radically different effects on the events on those routes. This is a similar example. Here we have a route that had 2 realignments made. One at the South end and another at the North end.

LRS Editing with Assets in Mind

- 1) Replace the entire route
 - Event effect: retire all events

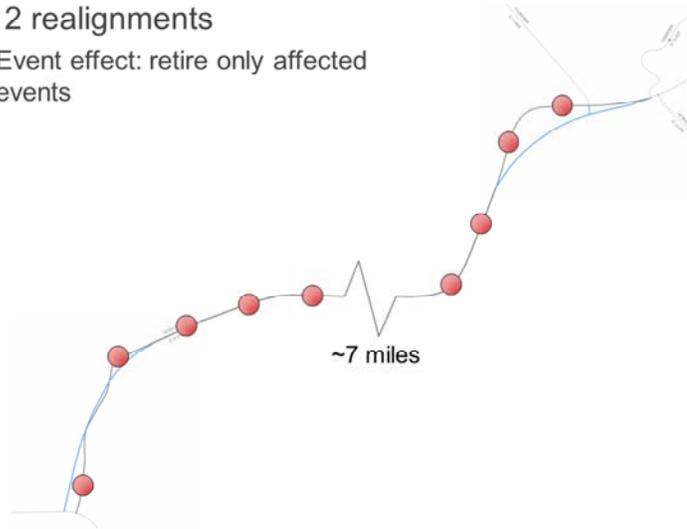


Let's say you have a feature that represents this route in its entirety with all the realignments already made. So, an easy way to make this edit would be to delete the old route with its old alignment and replace it with the new alignment. The trouble is that we are also editing events when we do this. By deleting this old route we are telling it to retire ALL of its event data. Even those events on the middle part where the route is unchanged. This kind of thing makes your event data owners very unhappy with you.

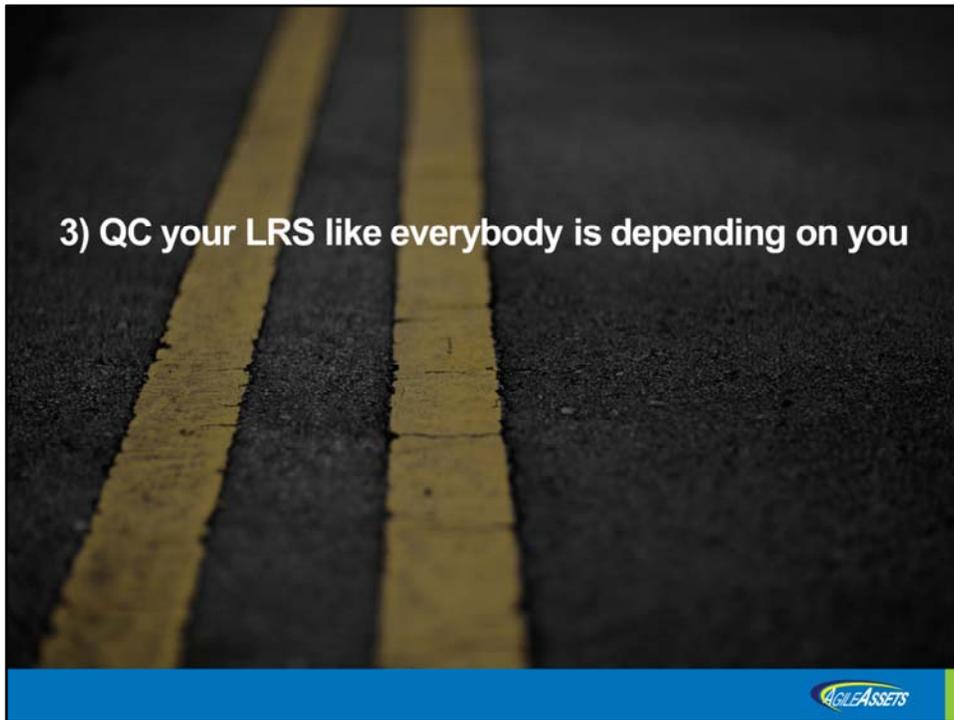
LRS Editing with Assets in Mind

2) Do 2 realignments

- Event effect: retire only affected events



So, the better alternative is to make 2 separate realignment edits. This way, only events associated with the pavement we tore up are retired. And this way you get to keep your event data owners smiling. So that is the 2nd lesson learned.



The 3rd lesson is to QC your LRS like everybody is depending on you. Because they are.

Data Quality

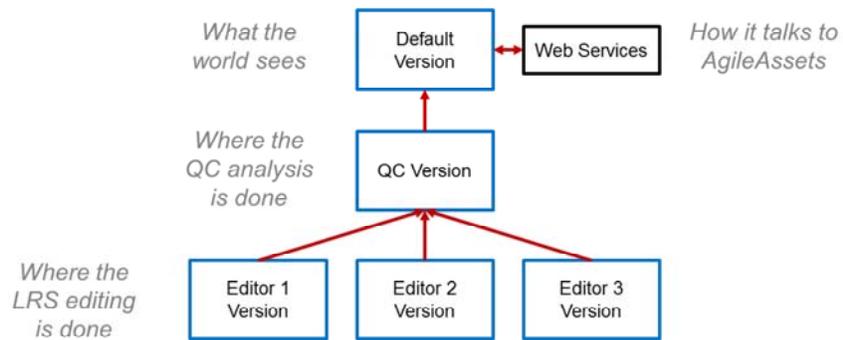
- Roads & Highways gives a lot of flexibility in how to implement QC
 - Data Reviewer, Python scripts, SQL queries
 - Make sure to include checks on vertex measures
 - Roads & Highways' Export Network web service is sensitive to vertex measure errors
 - Check for:
 - No ambiguous measures
 - No NaNs
 - No route portions with the same measures
 - Want steadily increasing measures
 - Pay particular attention to routes with multipart geometry



Roads and Highways doesn't really do any QC automatically. The bad news about that is that it is up to you to develop your own QC regime. The good news is that this gives you a lot of flexibility in how you do your QC. Of course you have Data Reviewer with a lot of built in checks and the ability to extend upon those. I hear in a talk that Jess Pearson did that MnDOT uses a lot of SQL queries to do their QC. A lot of my customers augment that QC with a python script we provided that goes through every route vertex-by-vertex and finds any number of things that may be lurking there. We have found this very important because vertex measures are largely invisible and it is easy to have problems that you never realize you have. But these problems can effect how useful your LRS foundation is to your agency. This same script also finds problems that happen on routes with multipart geometry. We have found that there are a lot of issues that can occur on these multi-part routes that may go unnoticed. So that is the first issue with QC.

Versioning Workflow

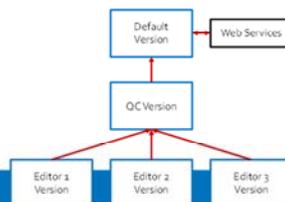
- Suggested versioning scheme



Next, let's touch on versioning. I think all of the users I know are using versioning so this is probably not a big item, but I wanted to touch on it. Here is one configuration that works well.

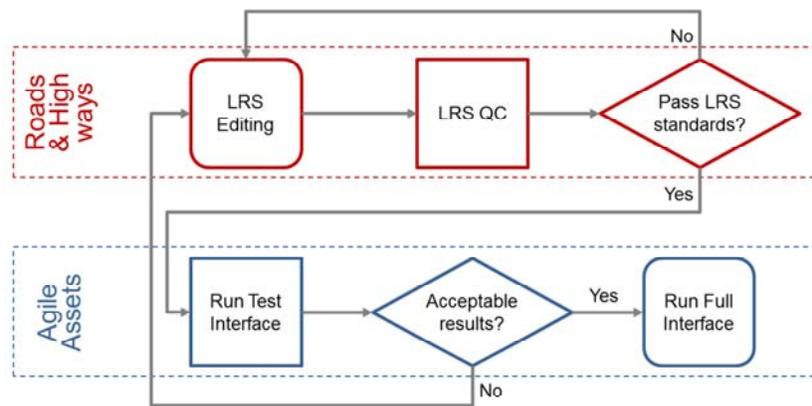
Versioning Workflow

- Editors do their work in the Editor versions
- They post it to the QC version so we can see all the edits in one place
- We QC within the QC version
- When satisfied we post it to the Default version for the world to see
- If we find any problems when running the interface we make the corrections in the QC version and then post to the Default version again



With this configuration the editors each have their own version. When they are done they post it to a QC version where all of the edits can be QC'd together to make sure all is well. Then, when QC is passed it can be posted to the default version. And this is typically where we attach the 2 web services we use in our interface. The end result is that the world doesn't see the updated network until it is in really good shape.

Workflow Suggestion



And this is my last slide on Lessons Learned. In this slide the top row shows the work that goes on in Roads & Highways, and the bottom row shows what goes on inside of our AgileAssets system. In the bottom row you can see we have an option we call test mode. This runs the 2 web services but holds the results in a buffer. With this buffer we can run our own QC and also can show the event owners how this interface run would change their events. And if they have some issues they can catch it before their production data is affected. This has been particularly helpful during the development phase of people's Roads & Highways implementations before they have all their QC tools in place.

Summary

- Get the most out of R&H by having it manage the LRS and event locations agency-wide
- Take advantage of these lessons learned:
 - Use right LRS Interface approach
 - Edit the LRS with Events in mind
 - QC your LRS as if everybody is depending on it

**Questions
& Answers**

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So that is what I have on enterprise LRS to make sure you get the most out of your LRS implementation. I am sure this is what most of you have planned and I hope that our lessons learned can be of some help to you. Thank you and I'd be pleased to take any questions you might have.