ITS4US System Requirements Specification (SyRS) Training Session Transcript (06-22-21)

Speaker: Deb Curtis

So, good afternoon or good morning depending on where you are. Welcome to the ITS4US task 6 System Requirements Specification Training.

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Hopefully by now all of you are familiar with me, but I am Deborah Curtis. I am a highway research engineer in the Federal Highway Administration Office of Operations Research and Development, and I am the systems engineering lead on the federal side for the ITS4US program.

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On the agenda for today, we are going to talk through the system requirements specification overview, and then we're going to break it down into a little more details related to the system requirements template which was sent out by Jim Larkin last Tuesday on 6/15.

If you did not get that please let us know and we will make sure that we send it out to you again. And I'm getting some feedback saying that the slides content can't be displayed. Can anybody see the slides? If you can, can you throw us a thumbs up in the reactions?

OK, I'm seeing plenty of those, so I see that we're probably pretty good to go. Alright, thank you.

So as I said, we're going to dive a little deeper into the template that was sent out to you and go over the four sections of that template. Which are the project overview, the general system description, the system capabilities, conditions, and constraints, and the system interfaces along with the appendix, which is the needs to requirements traceability matrix.

And then we'll wrap up with some final thoughts related to some useful references that we can send you to, and how you can stay connected with us in case you have any questions, concerns, comments, criticisms, critiques, or whatever after this presentation is over.

So next slide, please.

So, let us take a few minutes to review the program.

Although most of you are already familiar with it.

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So, this is a high-level summary of the complete trip ITS4US program.

As you can see there are multiple partners involved with this initiative with the goal of deploying innovative and integrated trips to support mobility for all users with a particular focus on underserved communities.

So, as you can see here, this involves the lead ITS Joint Program Office from the US Department of Transportation, but also involves the Federal Highway Administration and the Federal Transit. Administration. We are looking to make these large-scale deployments that are replicable and address the challenges of planning.

And executing all segments of the complete trip.

We would like to target all users across all modes regardless of location, income, or disability.

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So, we have 5 program goals.

And these program goals are spur high impact, integrated complete trip deployments nationwide, this first goal is to assist the transportation industry in tackling the difficult challenge of providing complete trips for all travelers nationwide by streamlining and expediting solution development.

Through pilot deployment.

Yes.

High impact, replicable integrated solutions developed by these pilot deployments.

Will reduce the cost of future deployments of these critical personal mobility enhancements.

The second goal is to identify needs and challenges by populations.

The needs and of the communities to support mobile mobility options for all travelers, regardless of location, income, or disability are important populations within each community have different needs and challenges for accessing transportation options to improve their quality of life.
The third goal is to develop and deploy mobility solutions that meet user needs.

This will allow us to take revolutionary steps to integrate advanced technologies, especially those that enable adaptive and assistive transportation technologies into the management and operations of the transportation network, including non-motorized modes.

Here we are.

Our goal is to engage key partners within the federal government.

The research community, stakeholder organizations, and private industry to support development of potential solutions for all travelers.

The fourth goal is to quantify and evaluate the impact of the integration of these advanced technologies strategies and applications.

The improvement of safety and mobility of all travelers, quantified impact support, communication of technology benefits to future deployers.

And decision makers.

And finally, the fifth goal is to determine which technologies, strategies, applications and institutional partnerships demonstrate the most potential to address identified barriers to providing complete trips to all travelers in a variety of communities and build environments.

This we also.

The goal is to disseminate the lessons learned from replicable solutions developed by the deployment sites to catalyze additional deployment.

The systems engineering process that we are going to talk about is critical to all of these goals.

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The US Department of Transportation has awarded five teams with Phase One funding to support the development of their deployment concepts. These five deployment sites include the University of Washington, California Association of Coordinated Transportation, Heart of Iowa Regional Agency. ICF International in Buffalo, NY, and the Atlanta Regional Commission.

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There are three deployment phases, and one post deployment phase.

Participants are currently in the first phase concept development where they will develop their ideas to ensure future success in later phases.

They will test and evaluate their projects.

The deployments are expected to sustain operation for at least five years after the program is completed

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So the system requirement specification is where your projects will start taking all the user needs that you compiled from your interviews and documented in your ConOps and begin decomposing them into a more detailed technical requirements.

The key components of your system requirement specification are the general system description, and this section should provide a high-level overview of the system under development. Most of the material in this section should come from your ConOps, which is why we were stressed defining your system of interest so much in task 2.

The next section is the system requirements and interfaces, and this section should decompose the system user needs into technical requirements that the system design and development team will use as the basis for their efforts. This is also where the system interfaces that map to specific standards or specifications should start to be defined.

And then finally the needs to requirements matrix shows the traceability between the user needs and the system requirements.

Every user need should have at least one requirement that it traces to. However, in general most user needs trace to multiple system requirements.

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So the USDOT strongly encourages all of the sites to use the template that we provided as the basis for your deliverable.

Because of the number of sites, five, that the USDOT has, we are requesting that all sites use the same template. This will make it a lot easier for us and more efficient for USDOT and the Noblis Technical Support contractor to review your deliverables and to provide timely and fast return of comments on your deliverables back to you.

So, as you can see here the due date for your review panel roster draft is mid-August. The final is at the end of August.

The system requirements specification draft is due September 20th with the final due approximately a month later in late October, October the 25th.

Your walkthrough workbook is do concurrent with your draft system requirement specification document on the 20th and then the walkthrough comment resolution report draft would be due on the 4th of October.

Again, like we did with the ConOps, we're planning to give you USDOT based comments first that you can then put through, you know, with your resolution matrix on the 4th and then finals would be due with your final system requirement specification document after your system requirements walkthrough is complete and you have an opportunity to include any comments or changes from your stakeholder community that you received during that walkthrough.

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So this diagram shows how the system requirement specification relates to other key deliverables within the project. For inputs we have the UNIRP and the ConOps obviously, and we'll also have the data management plan and the performance measures from task 5.

That will feed into the system requirement specification development and then you see after the system requirement specification every deliverable after that is something that you will use your system requirement specification for.

So tasks 7 through 14 are all dependent on the system requirement specification and also to note that you know this document will also be an input into a number of phase two deliverables, so it is really critical that we get this one right.

And where the UNIRP helped to define the processes for defining your user needs and your requirements, the system requirements specification is where you will actually develop your system requirements.

So the ConOps itself and the system requirement specification do take precedence over what was in the UNIRP. That was just to get you started thinking about your process, this is the actual deliverable that will be part of your foundation for your project.

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So let's go a little deeper into each of the sections of the template.

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Section one is your introduction, and your introduction should provide a high-level overview of your project. The main purpose of this section is to give your readers an overview of this system without having to read the ConOps.

Although using what you have already written for the ConOps is highly encouraged, this document does need to be able to stand alone.

Below there are additional sections to your introduction that you should focus on, including the purpose and the scope, and the system overview.

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In section 2 is where you should be focusing on your general system description and should use content like the context diagrams from your ConOps, and you may refer to your ConOps.

Although references are allowed, this document does need to provide enough information to give your readers a high-level overview of what the system is supposed to do, who the users are, and the major components of the system and the subsystems without requiring them to go back and read the ConOps.

So you don't have to reiterate everything that you had in your ConOps, but at a high level here you should give your readers enough information that they can get the gist of what you're talking about and what your system will be without having to necessarily refer back to the ConOps unless they want additional details.

So section 2.1, you should include a system context diagram to provide an overview of this system and to help define what's in the system, and where all the internal and external interfaces of the system are.

And since this document will start to define the technical requirements, it's really better to use the more detailed context diagrams from your ConOps.

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So this is kind of where we get into the meat of things and sections 2.2 to 2.6 expand on the information that you developed in your ConOps.

These sections should be consistent with the ConOps and/or updated to match the ConOps, so any information that you may change during your requirements definition needs to be reflected back in your ConOps to make sure that the two documents are consistent.

So section 2.2, system modes and states, should expand on sections 5.5 from your ConOps. The modes and states of the system should be explained and if needed a diagram should be included.

Section 2.3. should describe the major system capabilities and here it's important to reference and be consistent with the ConOps document for this section as well.

This section will introduce the organization or groupings for the system capabilities that should be used later to organize the requirements into logical functional groups.

Section 2.4, which is the major system conditions, constraints, assumptions and dependencies, should build on sections 4.5 and 5.6 of your ConOps and describe the assumptions and constraints that will be placed on the system and the impact the requirements will have on the system.

Additionally, any major conditions should be described such as other systems, infrastructure, or environments that will be present. Conditions may also include policies that have been put in place or agreements such as data sharing agreements with service providers that will allow your system to operate as designed. Any dependencies of the system should be included here and described.

In Section 2.5, which is user characteristics, you should describe the users of the system building upon section 5.3 of your ConOps. Each user group should be described, including how they'll interact with and use the system.

And finally, section 2.6, operational scenarios should provide a high-level overview of each of the operational scenarios or use cases from section six of your ConOps, with references to detailed operational scenarios or use cases if necessary.

If there are new operational scenarios or use cases that have been identified as part of this system requirements development process, they can be discussed here.

But again, they also need to be reflected in an updated ConOps to make sure that there is consistency between the two documents.

Next slide, please.

Section 3 will contain the well-formed requirements of your system, and much like a well-formed user, a well-formed requirement can be defined as a statement of the system functionality, a capability that can be validated and that must be met or possessed by a system to solve a customer problem or to achieve a customer objective and is qualified by measurable conditions and bounded by constraints. And that comes directly from the IEEE 1233, 1998 version.

So a good requirement will generally take the form of actor, action, target, constraint, and localization.

So if you look at the example we have here, the actor which is the system, takes an action which is in this case generates something that is targeted to alerts to travelers, but has a constraint about the closest accessible station exit, and a localization when the traveler exits the vehicle.

So here I want to note that when we use constraint for system requirement we are not using it in the same manner DOT's ADA regulations use it. Again, we are constraining the requirement by indicating any specific bounds that need to be designed against to meet user needs that we can then test against later in the systems engineering process.

If information about the closest accessible exit is needed by users in wheelchairs, as determined in the user needs gathering that you did, but the solution is only built to provide them with the closest exit, regardless of accessibility status, because the constraint was not part of the requirement you gave the team to design against, you will not meet your user need.

So the constraints are critical to ensuring that we meet the actual need of the user.

The system requirement template includes additional guidance on requirement writing, and I'll cover one more important part of that well-formed requirement on the next slide.

So next slide please.

Ok. So similar to well written user needs, and I think that we all went through the ringer on that with our ConOps to make sure that that the needs that we were writing were well formed and that they did convey the information that the stakeholders and then the end users had given us.

Similar to those well written user needs, it is critical that system requirements are also considered well-formed. So you can see the UNIRP or the system requirements specification templates for additional information on those criteria.

But here we have 11 criteria of best practices for system requirements that we want to walk through. So a requirement should be necessary. It should denote an essential capability. If this requirement is removed or deleted, it may cause a deficiency that is unable to be fulfilled by other capabilities of the product or the process. So requirements should be necessary.

Requirements should also be concise. The requirement simply and clearly states only one need. When a requirement is concise, the statement does not require any explanations, rationale, definitions, or descriptions of system use.

A requirement should be implementation free. The requirement does not need to state how it must be satisfied. The requirement states the desired result in functional and performance terms, not in terms of a solution.

Requirements should be attainable. The requirement should be achievable at a definable cost. Adequate analysis and trade studies show that costs are within the program cost constraints. So you know, we've often had times when we know that the best technical solution just is not feasible from a cost perspective, which makes it not necessarily attainable. So that would not be a good requirement.

The stated requirement should be complete. It can stand alone and it does not require further explanation. Each requirement states everything required on the topic and it stands alone when separated from other requirements.

Requirements should be consistent. The requirement does not contradict or duplicate other requirements. Organizing your requirements in accordance with a standard or a template facilitates the identification of inconsistencies. It's important to use consistent terminology throughout the

requirements document. Therefore, maintaining a glossary of program terms is one effective method for ensuring consistency.

Requirements should be traceable, and we'll hear a lot more about this later, but each requirement is traceable to its source, for example a trade study, ConOps, scenarios, and research results. A requirement also needs to identify related requirements such as parents or children's requirements.

Just like we had parent and children user needs, we can have parent and children requirements and other requirements that might be impacted by changes that you make to this one particular requirement.

Requirements should be unambiguous. Each requirement should have one interpretation. For a requirement to be unambiguous, the requirement must use language that leaves no doubt as to the intended description or numeric value. It should use common or well-defined words and phrases. And it should avoid using ambiguous words or phrases, and you see we have some of those listed here on the slide.

A big offender is capable of, what is capable of mean. Well, it can really mean almost anything, so best not to use those sorts of terms. Others are efficient, effective, best, approximate. You can read them for yourself, just make sure that you are not using words that can be interpreted in multiple ways.

Requirements should be verifiable. Each requirement must be verifiable by inspection, analysis, test or demonstration. A requirement must be stated in measurable terms to be verifiable.

And a requirement should be allocatable. Not sure that's a word, but it is today. Requirements should be allocated to the appropriate component within the system hierarchy and/or the appropriate organizational entities. For example to develop procedures.

And finally, requirements shall be style compliant. A style compliant requirement has a few qualities such as content, simple sentences, correct grammar and punctuation, positive statements, active voice, use of an appropriate directive verb.

And it also should have a proper format, and that means a paragraph number or paragraph title, subject, relation, value, capitalization, punctuation, and additional explanatory information in a glossary.

And I know that's a lot for a well-formed requirement and a lot of best practices, but really if we take these seriously and we implement these particular criteria I think that we are all going to come out with system requirements that are well formed and that do adequately reflect the needs of the system and the user community.

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So section 3.1 is the functional system and it should describe high level system requirements. In a more complex system, it may be necessary to break these down into subsystems. These requirements should contain the core functionality of the system and the needs.

As an example, many of the ITS4US projects may have a back-end software system, mobile device applications, and web applications. Those sorts of things and from a future design and development standpoint it may be very beneficial to define those as separate subsystems with their own

requirements. This can make it a lot easier later to divvy up the requirements between the design and development teams and to make sure that if you make changes to one that it is reflected appropriately.

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Section 3.2 is the physical aspects of the system. This subsection will describe the physical requirements of the system and most likely be hardware or infrastructure requirements of the system. There are four categories given to break physical requirements into construction, durability, adaptability, and environmental conditions.

So let's go a bit deeper into each one. Construction requirements include requirements on the physical location and the design of the system, hardware, and infrastructure. If there is a type of installation that will happen many times, such as installing a device at a traffic signal or bus stop, generalized requirements can be used, while localized requirements should be determined in installation plans/designs later on.

These requirements can include things like physical network connection, infrastructure and hardware placement size, positioning, power, connectivity, or other functionality.

The next great category is durability. This will include requirements related to the durability of the system, such as what conditions it must be able to withstand. The section may also specify when a part of the system, infrastructure, or hardware should be replaced, which is anticipating lifecycle replacements.

The next criteria is adaptability, and this describes requirements related to growth, expansion, contraction, or other adaptations the system must be able to handle. Examples may include anticipated user growth, bandwidth increases, storage increase, and hardware and software updates, those sorts of things.

Many of these requirements deal with the how the system will continue to operate in the future as new technology is introduced, standards evolve, or other changes arise that can affect this system.

And finally, environmental conditions document requirements related to environmental conditions that the system must operate in. This may include things like winter or summer weather, environmental conditions of vehicles, noise levels in busy transit centers, or even light levels in underground transit centers.

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Section 3.3 is the system performance characteristics and will define the performance requirements of the system. It should include quantitative performance characteristics that the system shall meet to fulfill user needs. These may include time-based functions that must happen within a given amount of time (for example API response times, app load times, maximum allowable latency of data transmission) or dynamic actions that must occur at a certain rate. For example, speed, noise level and volume in decibels, brightness in lumens or nits.

And as previously stated, performance requirements should always be quantifiable. We cannot effectively validate what we can't measure.

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Section 3.4 is all about system security and privacy, and this section will specify requirements for both cyber and physical security of the system. So protecting personally identifiable information (PII) is a top priority, especially for the complete trip ITS4US Program.

So your requirements must address security and privacy of data as you've defined in your task three data management plan.

But we also must address security requirements that may already exist in some device documentation, vendor procurement documents, or a security management and operations plan from an organization on your project team. These can be referenced in your document as long as the referenced document is available to others for review, or it can be copied directly into your document if allowed.

It's also critical to include any requirements of the system to protect the physical security of hardware, infrastructure, or users. And this section will generally deal with protection from external actors. People looking to hack your system.

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Section 3.5, which is information management, specifies detailed requirements of the system to protect and manage information and data within the system.

So whereas the previous section was related to external actors, this is talking about managing and protecting data within your system.

This section should detail requirements within the system to manage user privacy and data such as passwords, access levels, etc. This is also where you may need to define requirements based around constraints associated with the information technology environment your system will operate in.

Many municipalities run their own IT networks and have existing IT and information management requirements that must be met in order for you to use those networks.

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Section 3.6 talks about system operations, which are subdivided into sections on human factors, maintainability, and reliability. The system human factors contains requirements pertaining to all interactions between the user and your system.

This section will be particularly important for the ITS4US program as each deployment will need to meet the needs of the identified in task 2.

This includes users with disabilities of any type or possibly multiple disabilities, travelers of low-income, older adults, people with low-English proficiency, and other underserved populations that each of your sites identified earlier in the systems engineering process and had meetings with to gather user needs.

So the program will need to accommodate these requirements.

These requirements should define the usability, ergonomics, and other critical attributes of the system to serve these underserved communities and users.

System maintainability contains quantitative requirements regarding maintenance activities and support of the system.

These requirements may set time requirements for mean and max downtime, reaction times, turnaround times, or repair times. It may also describe rates for hours per specific maintenance action, maintenance per operating hour, and frequency of preventive maintenance.

Other maintenance requirements may include support equipment needed, staff experience requirements, and staffing level requirements. This section should include planned and emergency maintenance.

And finally, system reliability contains quantitative reliability requirements and conditions under which the requirements are to be met. This section should relate to the modes of operation that you defined previously in the ConOps and how the system maintains reliability and safeguards.

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Section 3.7 should build on the policies described in section 5.6 of your ConOps and detail the requirements of the system needed to meet the policies. This should include any organizational policies, external regulatory requirements, or constraints that may impact the operation or the use of the system.

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Section 3.8 should describe the system lifecycle sustainment which includes any quality control and assurance activities, such as review, and measurement collection and analysis, to help deploy a quality system.

Over time, new technology, user needs, and ideas will arise as the system moves through the lifecycle.

Data needs to be captured and analyzed to determine what impact these possible enhancements will have on the systems engineering process and the system.

Any requirements of the system related to remaining in quality operation throughout its entire lifecycle should be described here.

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And finally, Section 4 describes your system interfaces. This section should include requirements for internal and external system interfaces. Internal system components will need to communicate. This may include interfaces between hardware, the system and operators or the system and its users.

External interfaces between the system and other systems should also be covered. The interdependencies should be included in the requirements as well as information such as communication protocols, standards to be used, and formats.

Graphical representation of your interfaces can be invaluable. There are many projects that want to utilize standards and specifications for certain interfaces and this is where those types of interface requirements can be defined.

Given the extensive number of external interfaces that were noted in the ConOps walkthroughs over the last few weeks, it's evident that this section is critical to the success of your ITS4US project.

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And finally, we'll get to the appendix, and that is your needs to requirements traceability matrix. The development of your needs to requirements traceability matrix will quickly highlight any gaps that exist within your system requirements and allow you to address those gaps early.

A best practice is to generally track traceability between a user need and a requirement during the initial development process. Then as the requirement space stabilizes, you should create your needs to requirements traceability matrix.

This traceability will form the basis of the traceability to design test cases and test procedures as the systems engineering process continues.

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So an example matrix is provided on this slide. The shaded rows are used to show the user need with the associated ID placed in the left column, followed by the need title in bold and the need text in plain text in the right column.

Underneath each need are the associated requirements, uniquely identified in the left column (from sections three and four above) with the text of the requirement provided in the right column.

It is important that every single user need identified in the ConOps during task two is included in your needs to requirements traceability matrix.

The example on the slide shows just one need and one related sub need, of which there would be several. Continuing with this example, you would have separate but related needs regarding information necessary to provide to blind or low-vision users that would differ from the information that would be needed to be provided to people in wheelchairs.

If a different format than this is desired to be used by your site, please share with your COR and your site support team for confirmation that it includes all the necessary components before you develop your needs to requirements traceability matrix.

You will need to use a format that works for your team, but also you need to use one that allows everyone to understand where the requirement came from.

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So let's wrap it up with some final thoughts. I know I have thrown an awful lot of information at you in a very short period of time, but let's go to the next slide.

So not only will there be a recording of this available for you all to refer back to, we've also compiled a list of useful references here, which some you have seen before.

They include federal highways systems engineering documents, documents from peer agencies like the North Dakota State department of transportation, the IEEE documents that we referred to early in the presentation, which must be purchased. But as we confirmed before, you can use project money to purchase them.

And also included here is a NASA resource that was included in the template that we sent you and contains some really great information on how to write a good requirement.

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As always, here is the contact information for Elina Zlotchenko, who is the program manager for the entire ITS4US program, my contact information as your systems engineering lead from the federal perspective, and a couple of websites where you can visit to get more information.

I will again stress if you want to reach out to Elina or myself, please ensure that you include your site COR so that they can be informed of all that is going on with their particular project as they're the one responsible in the end, for your success.

But we look forward to providing you with support and help just as we did for ConOps development, and I'm sure these will be just as successful.

So next slide please.

At this point in time, we're going to go ahead and I believe, pause the recording and open it up to questions.