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CONNECT THE DOTS:

Five tips on traceability to skillfully control change & improve quality.

What is traceability? It sounds complicated and like a lot of work. Is it really worth the effort? The short answer – yes. And here's why: Change happens.

If managed poorly, change will wreak havoc on even the most talented and experienced development teams. If managed skillfully using tools like traceability, teams are better equipped to assess the impact of changes, track the full history, keep everyone in sync and (deep breath) consistently improve the quality of the products being built – every project, every release.

In some industries, traceability isn't an option, it's mandated. We'd recommend that regardless of the industry you're in or the process you use – whether you're building components for commercial airplanes using waterfall or designing the next killer iPhone app using an agile method –traceability is a best practice that will benefit your team.

In this paper, our goals are to demystify traceability and its related concepts, and provide five practical tips to help you take control and keep everyone in sync.

Master traceability – the five tips.

1. Create relationships to connect everyone and everything together with Trace Relationships
2. Ensure you have proper coverage using a Traceability Matrix
3. Assess the impact of a change before it occurs with Impact Analysis
4. Document changes for complete visibility and a detailed audit trail with Version History
5. Keep communication flowing and the team in sync with smarter, real-time Email Notifications

> "Companies with mature requirements management and traceability processes achieve 75% higher success rates."
>
> IAG, Business Analyst Benchmark 2009

Challenges

Swimming upstream or downstream without a trace is risky business.

Do these scenarios sound familiar? You just got a great piece of feedback from your best customer mid-project, and a high-level business requirement needs to change. How will this change impact the functional requirements your developers are working on right now? How will it impact scope for the upcoming release? Your QA team just found a deal breaker of a bug in your most popular new feature and you're two weeks away from launch. Do you ship with the known bug or delay the launch? Who is working on that feature? Who else needs to be notified and weigh in on the decision? What else does it affect? These scenarios occur daily for development teams. So, how do you deal with them? One of the tools in your arsenal is traceability.

Is traceability worth it? One common challenge that teams face in implementing traceability is the incremental time and costs involved. There's no question that in order to do traceability well, there is a time investment that's needed up front to set-up the trace relationships and configure coverage reports. However, the incremental costs incurred with using traceability are small compared to the time and money you will save further along in the development process due to the benefits that traceability provide.

Benefits

Your ticket to great project success: on time, on budget and within scope.

For most organizations, the benefits outweigh the time required to set-up traceability by at least 2x. With a consistent process, structured templates and a modern requirements management tool, much of the process can be automated and streamlined. Even if you opt to manage it manually, traceability offers several valuable benefits to your organization:

- **Minimize risk**
- **Control scope changes**
- **Improve quality**
- **Reduce development costs**
- **Grow productivity**
- **Complete test coverage**
- **Increase visibility**
- **Accelerate innovation**

Terminology

Demystify traceability & related concepts.

Before we dive into the five tips, let's take a moment to define a few terms to make sure we understand the lingo. For a more in-depth explanation, click on the term to visit the related Wikipedia page (if available).

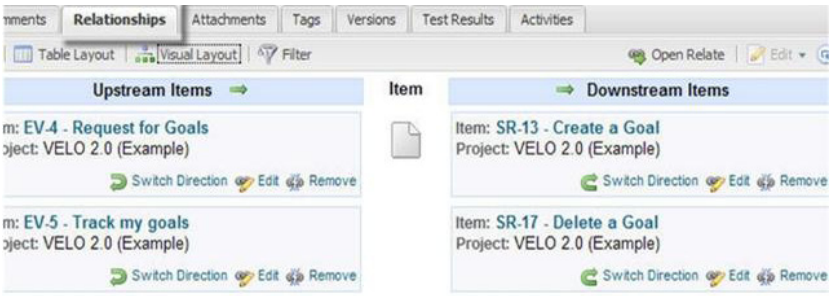
traceability	Traceability is a sub-discipline of requirements management. Traceability documents the life of a requirement, tracks every change and links its relationships with other items within a project.
trace relationship	A link between items within the scope of a project, used to help assess impact on other items when a change occurs.
upstream	Upstream relationships, aka backward traceability, looks at the links between detailed functional requirements back up to the original customer need and high-level requirements captured. It's used to ensure that the evolving product remains on track in regards to the goals of the product and what customers need. Helps to avoid scope creep and gold plating.
downstream	Downstream relationships, aka forward traceability, looks at the links between detailed functional requirements, test cases, tasks, defects and other items that support it. It's used to ensure that you're building the right product.
traceability matrix	A traceability matrix is created by associating requirements with the work products that satisfy them. Often it's used to track tests associated with the requirements on which they are based and the product tested to meet the requirement.
impact analysis	Using impact analysis, the traceability links between requirements, specifications, design and tests are captured, and these relationships can be analyzed to determine the scope of an initiating change.
version history	Used for change control, a detailed history of each requirement and other items is documented and stored in a unified system of record, enabling complete audit trails used over the life cycle of the requirement. Required for industry compliance in specific industries such as aerospace and medical devices.
suspect links	Suspect links help manage the impact of requirement changes. A trace relationship (or link) becomes suspect after a requirement in the relationship changes. A suspect links report is often used along with Impact Analysis for assessing impact before making a change.
CMMI	Created by the Software Engineering Institute, CMMI models provide guidance for developing or improving processes that meet the business goals of an organization. As it relates to traceability and requirements management maturity, see levels 2 – 3.

ONE: TRACE RELATIONSHIPS

It's like the six degrees of separation from your business objectives. We managed to slip in a Kevin Bacon reference not only because we're fans of the movie Quicksilver, but also because it relates to product development. As in many aspects of life, your product development success is highly dependent on relationships. All of the details such as user requirements, functional requirements, test cases and other items that define the scope of what you're building are related in some fashion, either directly or indirectly. Here's an example of a common process flow:

business objectives	user requirements	functional requirements	QA test coverage
What's the vision for this product?	What's the story of what users need?	How should it work to fulfill the needs?	Which issues are to be resolved?

Using trace relationships you can connect everything together to map out the interdependencies between the different items. These relationships are the foundation for doing traceability effectively. As an example, here's a screenshot of a Visual Traceability Layout showing both upstream and downstream items related to this requirement (item).



In addition, trace relationships are as much about connecting together the people involved as it is about connecting together all the items. Each requirement in the system has customers, stakeholders and members of your team associated with it. There are analysts who own defining it. There are developers building it. There are QA engineers testing it. And, there are stakeholders and customers who care about its status.

When one item changes it has a ripple effect on other related items and the people associated with the items. Keeping track of this ripple effect is crucial to the success of your projects. It's one of the primary reasons organizations do traceability.

TWO: TRACE MATRIX

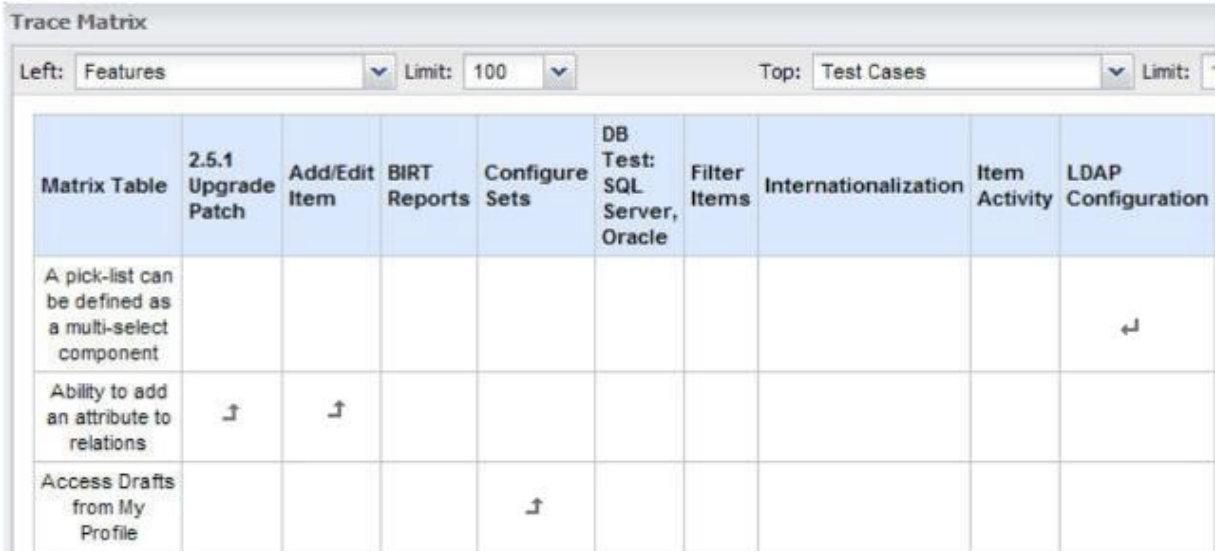
Mr. Anderson – Welcome to the Traceability Matrix. (And now a reference to The Matrix...) In all seriousness, a Traceability Matrix isn't science fiction. It's very real and can be a valuable report for helping you ensure complete test coverage. For a manual example of a Traceability Matrix, you can build one in Excel, such as this one courtesy of Joyce Ludwig.

ID	User Requirements	Forward Traceability
U2	Users shall process retirement claims.	S10, S11, S12
U3	Users shall process survivor claims.	S13

ID	System Requirements	Backward Traceability
S10	The system shall accept requirement data.	U2
S11	The system shall calculate amount of retirement.	U2
S12	The system shall calculate point-to-point travel time.	U2
S13	The system shall calculate the amount of survivor amenity.	U3

This simple insurance claims system example shows both forward and backward tracing between user and system requirements. User requirement identifiers begin with "U" and system requirements with "S." Tracing S12 to its source shows this requirement is problematic, and should be rewritten to support the processing of survivor claims or the traceability link corrected.

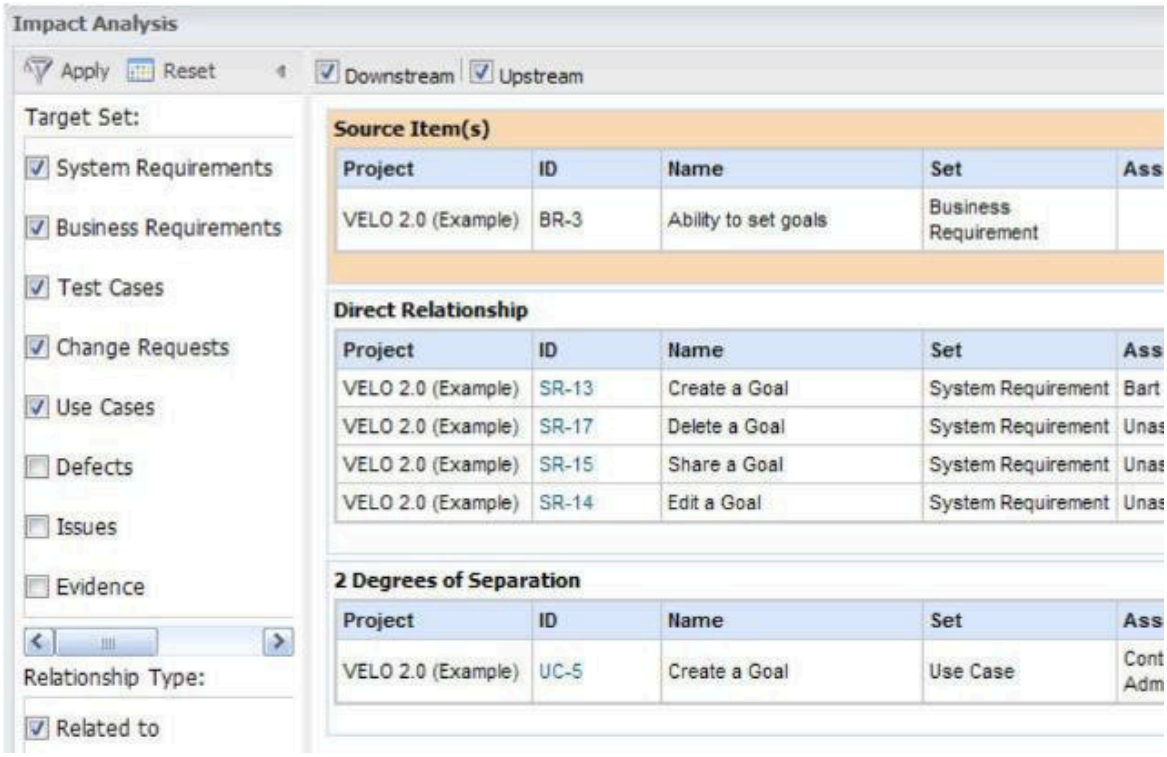
Here is an example of an automated traceability matrix generated from Contour. In this example, the matrix is reporting on the relationships between Features and Test Cases. This is useful to identify gaps in test coverage, which is a popular use of a traceability matrix to ensure each feature is properly tested before its release.



THREE: IMPACT ANALYSIS

It's your virtual crystal ball looking into the future. What if you could anticipate the impact a change would have on your project and the entire team before it occurred? Will this change request send the development team over the edge or do they have bandwidth to squeeze it into the next release? These insights are possible without pixie dust – instead, Impact Analysis. Impact analysis relies on the trace relationships you've set up, and it reports on the complete picture of all the items that are affected – both directly and indirectly.

Here's an example of an automated impact analysis report for a high-level business requirement. If it were to change, four directly related system requirements are affected and one indirect use case is also impacted.



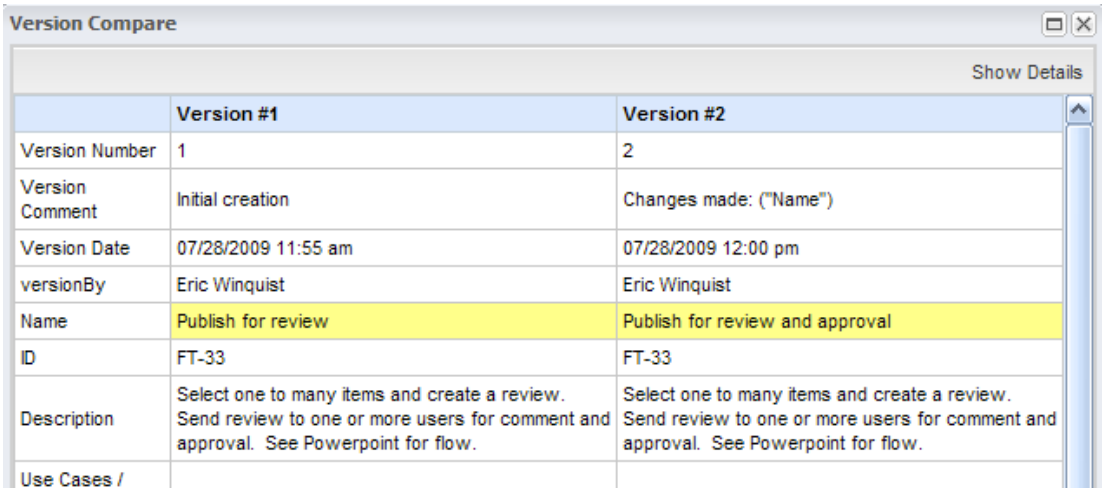
If only we could apply impact analysis to other aspects of our lives, like the decision to have that second helping of pumpkin pie on Thanksgiving. What's the impact on "Project Fat Tire"? Oops, we better expand the scope on that one and push out the release date until New Year's.

FOUR: VERSION HISTORY

If you prefer things at a high-level, and don't like to dive into the details, look away. This isn't for you. This tip on Version History is for those among us who like to roll-up the sleeves and get deep into the glorious details of every change. It's also been humorously referred to as the "CYA tip," for coverage of a different kind.

Personal motives aside, capturing a complete and detailed record of all changes is a critical element for reaching higher levels of requirements maturity within your process, such as CMMI. It's also helps companies meet industry compliance standards in specific fields such as aerospace and medical devices. One of the benefits of doing traceability is having a comprehensive audit trail of changes, so you can analyze who, what, when and why a change occurred. At the same time, you can easily roll-back to an earlier version if needed because it's all stored in the unified system of record.

Here's an example of a side-by-side comparison of two versions, using an automated process within Contour. For efficiency gains, the specific field that changed is highlighted in yellow, so you don't have to spend time hunting around the full requirements specification document to pinpoint and understand precisely what changed. Viva la details!



	Version #1	Version #2
Version Number	1	2
Version Comment	Initial creation	Changes made: ("Name")
Version Date	07/28/2009 11:55 am	07/28/2009 12:00 pm
versionBy	Eric Winquist	Eric Winquist
Name	Publish for review	Publish for review and approval
ID	FT-33	FT-33
Description	Select one to many items and create a review. Send review to one or more users for comment and approval. See Powerpoint for flow.	Select one to many items and create a review. Send review to one or more users for comment and approval. See Powerpoint for flow.
Use Cases /		

As with the other aspects of traceability, you can track version history manually through static documents using versioning. It's just more cumbersome and time consuming to manage complex projects that way.

> "We use Contour to provide a clear workflow of our requirements change and ensure proper test coverage."
>
> Christopher Moustier, QA Manager,
> Wyplay Home Entertainment Systems

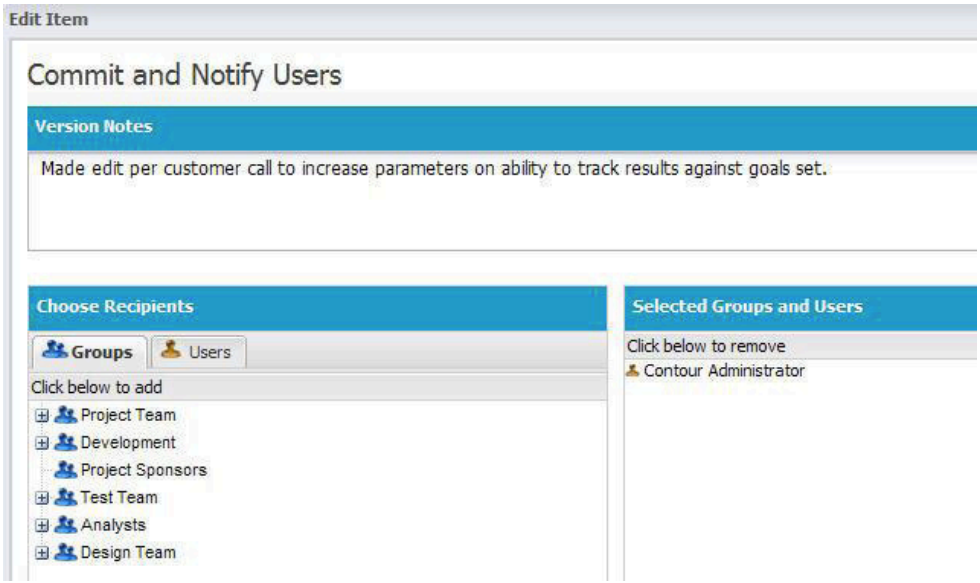
FIVE: REAL-TIME COMMUNICATION

Avoid Noise. Communicate changes quickly & intelligently. How often have you been involved in a project where "change notice paralysis" sets in after about 3-4 weeks of inbox overload? Usually it occurs when the entire team is on a project-wide distribution list and the project manager is on the hook to send out an email with the complete 200-page Software Requirements Specification document attached for every little change that occurs. Right intention, wrong solution. What happens next? People either waste time hunting around in the requirements spec trying to determine if the latest change is relevant to them – which is costly. Or, they tune out the email barrage as noise and become vulnerable to missing a change that is important to what they're working on – which is even more costly.

> "Contour is flexible, easy to use and gives us complete traceability for all of our requirements."
>
> Erik Johansson, Software Engineer,, W.M. Keck Observatory

There are smarter ways to keep everyone on the same page. You need to be sure that everyone who is impacted by a change is in the loop. At the same time, you don't want to flood the entire organization with irrelevant emails. What do you do?

In the example below using Contour, when a change occurs, you can instantly send a direct link to the specific requirement that changed with version notes to just the relevant groups or individual users that are affected by it. The notification step is then part of the overall change management workflow. Stay in the loop. Avoid noise.



Automate Traceability

Accelerate development by 50% & improve quality 2x by automating traceability.

You can manage traceability manually using Microsoft Word or Excel documents. That's a real option. For small teams and simple projects, that's probably all you need. We've provided links to a few free templates courtesy of industry experts that you can use to manage traceability manually:

- Traceability Matrix Template (.xls), courtesy of CDC.gov, requirements management templates
- Impact Analysis Checklist (.doc), courtesy of Karl Wiegers, Process Impact

What's the right time to automate? The challenge with a manual solution is it can be extremely time consuming and cumbersome if your projects have any level of complexity – meaning you have many requirements, frequent scope changes or remote members of your team working from different locations. In these scenarios, automation can provide a huge boost to productivity, saving you time and money in the long run. Automation also minimizes the risks of human error, which is always possible despite the best intentions and most skillful staff.

What's the ROI? The return on investment is different for every company, but through our experience, we've seen as high as a 42:1 benefit-to-cost ratio for a global entertainment company. For most organizations, as a conservative benchmark, you can expect to speed development cycles by at least 50% and improve quality by 2x or more within the first 6 months using a requirements management solution that automates traceability.

If you're interested in automating your process, we recommend you evaluate a few different requirements management tools to find the right one for you. As one option, you can explore the traceability features of Contour. It's designed specifically as a collaborative, Web-based platform to help teams solve the traditional requirements management challenges and automate traceability, so you can reap the rewards:

- Save time and money
- Accelerate development cycles
- Improve quality and compliance

Take Action

Take the next step in mastering traceability & watch the 5-minute how-to video.

Concepts are nice but actions rule. Click the play button to watch the video & access other resources to help you implement traceability.

Roll the Credits

Footnotes on statistics & articles we referenced during our research. Enjoy.

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2. "Systems Engineering – Top Four Design Tips to Increase Profit Margins for Mechatronics and Smart Products", Michelle Boucher, Aberdeen Group, November 2009
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6. Wikipedia definition of Traceability http://en.wikipedia.org/wiki/Requirements_traceability
7. "Bidirectional Traceability," by Linda Westfall, the Westfall Team
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9. CMMI overview by SEI
   http://www.sei.cmu.edu/cmmi/

About the Authors

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John represents the voice of the customer in Jama's product strategy and communications. He has over 14 years experience working at software and Web technology companies including Microsoft, WebTrends, Omniture and ZAAZ. He has contributed to several books, whitepapers and presentations on marketing and technology.

Eric Winquist, CEO & Co-founder

Eric founded Jama with the vision of providing customers a more collaborative way to develop new products and eliminate the common frustrations with traditional approaches to requirements management. Eric is an accomplished entrepreneur, business analyst and project manager with over 15 years experience working with a wide range of organizations. Previous to Jama, Eric founded Redside Solutions, a software development consulting firm.

About Jama Software

Thousands of users worldwide. Billions in R&D projects managed within Contour.

Jama Software is the leader in collaborative requirements management solutions for improving enterprise collaboration and managing complex software development projects. Its Web application, Jama Contour, helps organizations manage the entire requirements management lifecycle through an intuitive, easy-to-use interface that brings people, process and data together to ensure software quality is delivered as specified.

Customers, from agile start-ups to the largest and most sophisticated technology and IT organizations in the world, turn to Jama to help drive innovation, improve the decision-making process and harness the collective genius of all stakeholders involved in building great software. For more information please visit: http://www.jamasoftware.com.