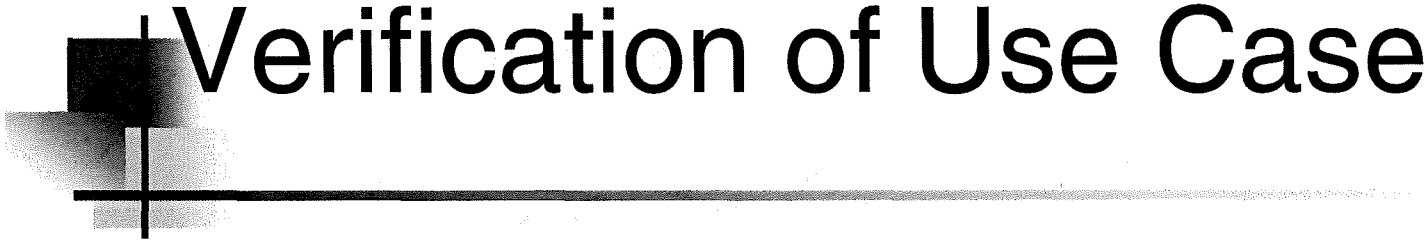


Verification of Use Cases (VUC)

Shannon Bouldin

SELP 695 - Integrative Project

December 11, 2010

VUC Outline

- Introduction
- Benefits
- VUC Method
- Example
- Results
- Conclusion
- Questions

VUC - Introduction

- Requirements phase
  - 40% of all project failures
  - 60% of all project errors
  - 10 to 20 times less costly to fix
- DOD Acquisition Process Overhauled
  - Requirements now addressed in Pre-System Phase
- Imperative to *Build Right System*

VUC - Introduction

- Requirements analysis
  - 40% of all project failures
  - 60% of all project errors
  - 10 to 20 times less costly to fix
- DOD Acquisition Process Overhauled
  - Requirements now addressed in Pre-System Phase
- Imperative to *Build Right System*

VUC - Definition

- ***Verification*** *is the process of evaluating a system or component to determine whether the products or deliverables from a given development phase satisfy the conditions imposed at the start of that phase, rendering formal proof of a program correctness (Wasson, 2006)*
  - **Proving that the right system was built**
- ***Use Case*** *(UC)- Statement that express how the user envisions deploying, operating, supporting or disposing of a system product, or a service to achieved a desired performance based outcome (Wasson, 2006)*
  - **Illustrates the Functional Requirements of the system**
- *VUC - Verification of Use cases*
  - *Method to track and flow down use cases thru design process, and build test cases from the use cases to allow subsystems to be tested to their system requirement. Proving that each level of a system fulfills the customers wants.*

VUC - Benefits

- ***Lean Systems Engineering*** *- the application of lean six sigma principles, practices and tools to system engineering in order to enhance the delivery of value to the systems stakeholders.*

- INCOSE states that the Lean Enablers for System Engineering are captured in six lean principles:
  1. **Customer defines Value**
  2. Map the Value Stream
  3. **Make Flow Continuous**
  4. Let the Customer Pull Value
  5. **Pursue Perfection**
  6. **Respect People**

VUC - Benefits: Lean Principals

- Customer defines Value

  the initial phase of every program should not only capture the comprehensive, unambiguous, and detailed understanding of value to the customer, but also the needs, context, and interpretations of the requirements.

  - VUC confirms customer needs are met at all levels of the design process
  - Reduces uncertainty
  - Encourages frequent interaction w/ customer
  - Capture, develops, and disseminates value w/ clarity
  - Promotes 'customer first' & 'first time right' culture
    - Added cost for up front work negated by saved cost of no backend work
  - Example: A12 Avenger II
    - Failed Requirements: Carrier based & Stealthness
    - Largest contract termination in DOD history

VUC - Benefits: Lean Principals

- Make Flow Continuous

  Flow is to work through the planned and streamlined value adding steps and processes, without stopping or idle time, unplanned rework, or backflow

  - Clarification, derivation, and prioritization of Req
    - Accomplished by utilization of UC's
  - "Fail early - Fail Often" through rapid learning technique such as testing
  - VUC incorporates UC's into Req doc
    - Gets the SE and TE to work as partners
  - Communicates all expectations, context, and need to the supplier

VUC - Benefits: Lean Principals

- Perfection

This principle strives for excellence and continuous improvement of the SE process and related Enterprise Management.

  - Makes imperfection visible
  - Problems not passed along
  - Not relying on final inspection

- Respect for People/System

  This principle promotes high level of human relations at work based on respect for people.

  - Have a vision which draws & inspires best system
  - Use flow down of Accountability
  - Example: Southwest Airlines
    - Employees know that their work contributes to meeting goals of corporation
    - Ensures subsystem will indeed contribute to system goals

VUC - Method

- Tracking
  - UC: V4R18UC1
  - TC: V4R18TC2
    - Any Tracking method works
      - Child Requirement ID'ed
- Use Cases
  - Any format works
  - Important to have story/scenario's

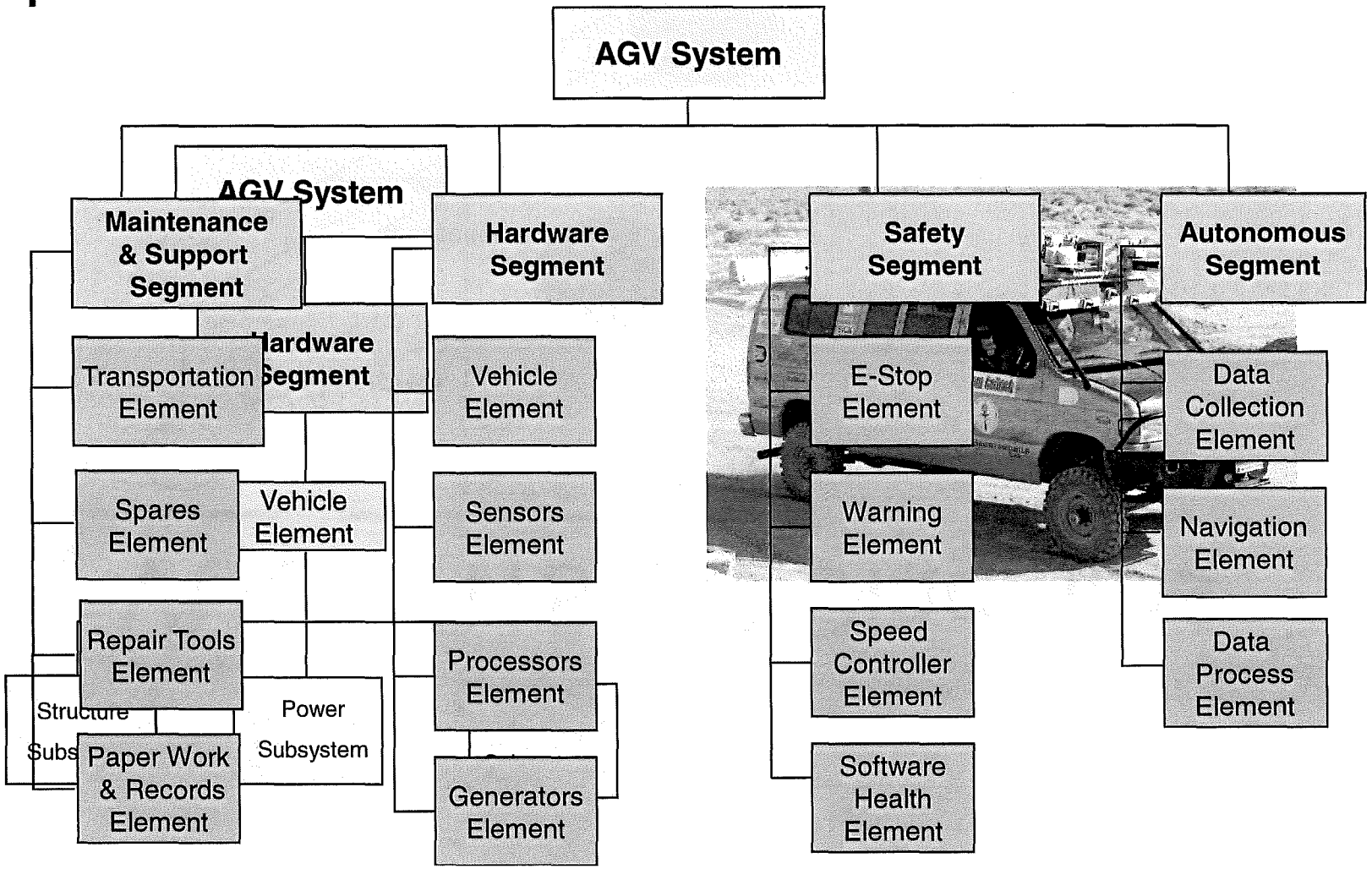
VUC - Method

- Test Cases
  - Requirements and UC's in same doc
    - Flowed down to Test Engineer (TE)
  - Generate from UC
    - Jim Heumann's method
      - Test Case Matrix states validity and applicability per scenario
      - Expected test output added, used to test system against
      - TE actually tests to what the customer wants, not someone else's interpretation of what the customer wants

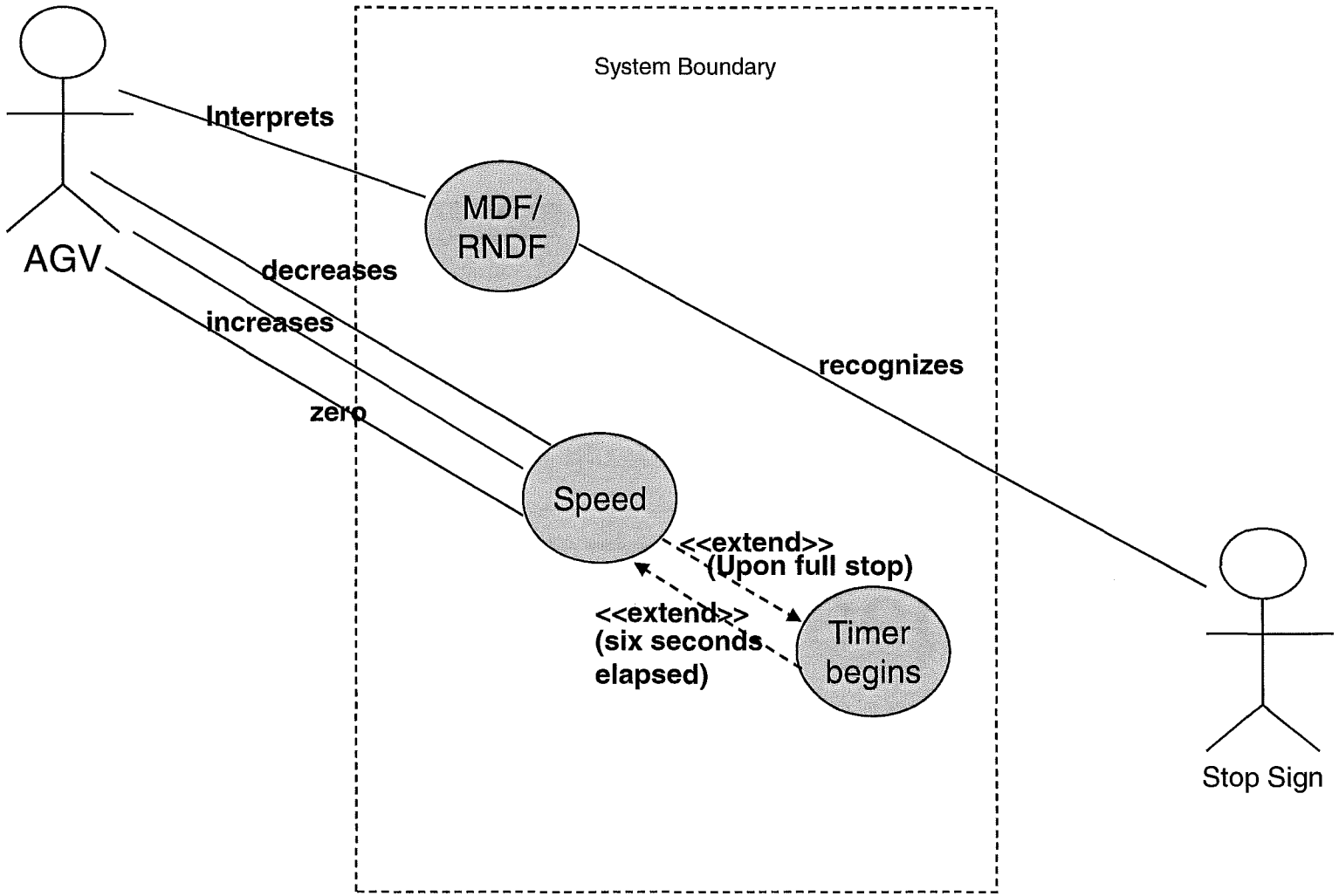
VUC - Example

- Autonomous Ground Vehicle (AGV)
  - Robotic vehicle designed for DARPA Urban Challenge
    - Goal to safely and effectively execute military relevant missions
    - 60 miles in less than 6 hours autonomously
    - GPS as guide
    - Obey CA driving and traffic laws
    - Average Speed of 10 mph, Top speed of 30 mph
    - Designated course provided day of event
      - consist of any scenario that normal vehicles face in urban environment
    - Obstacle Avoidance
    - Emergency Safety System

VUC - AGV Architecture



VUC - R18 UC Diagrams



VUC - AGV Example

System Requirement: **R18UC Name: Stop Sign**

- *Description:*

  This use case covers the AGV stopping with in ("with in" should be one word. fix in multiple places) 1 meter of stop line at a stop sign and resuming movement with in 10 seconds. **R18: Vehicle shall stop safely within 1 meter of the stop line at a stop sign intersection and proceed with out excessive delay (less than 10 seconds) according to intersection precedence rules**

- *Actors and Goals:*
  - 1) AGV to stop
  - 2) Stop sign to be obeyed

- *Assumption and Precondition:*
  - 1) Requirement #9
  - 2) Requirement #10
  - 3) Requirement #2
- AGV in autonomous mode

VUC - AGV Example

- *Basic Course:*
  - 1) AGV interprets MDF and RNDF
  - 2) AGV recognizes that stop sign is approaching in 10 feet
  - 3) AGV slows down
  - 4) AGV comes to full stop within 1 meter of stop sign line
  - 5) Timer begins upon stop
  - 6) AGV waits 6 seconds before proceeding
  - 7) AGV resumes moving on DARPA specified path

- *Alternatives:*
- None

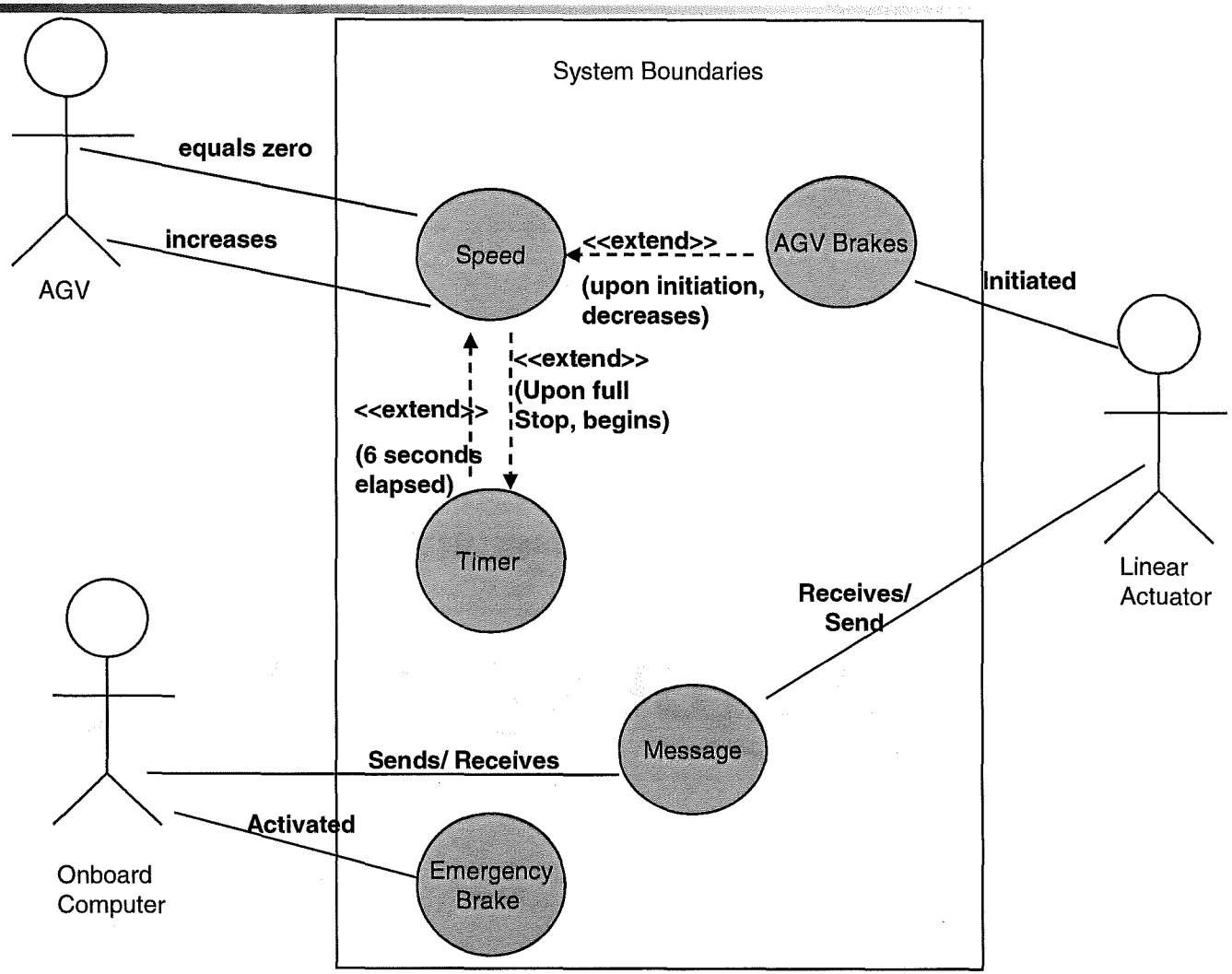
- *Post Condition:*
- Before 10 seconds is elapsed, AGV has resumed movement

APPENDIX

Table 3: AGV System Requirment Test Case

		Test Cases																		
Test Case ID	**Scenario**	**AGV has GPS coverage**	**AGV out of GPS coverage range**	**MDF & RNDF interpreted**	**MDF & RNDF NOT interpreted**	**Waypoint = stop sign approaching**	**AGV decelerates**	**AGV accelerates**	**AGV speed = zero**	**Stop sign line = 1 meter from AGV front bumper**	**Stop Sign line <1 meter from AGV front bumper**	**AGV timer starts**	**AGV timer does not start**	**AGV timer >/= 6 seconds < 10 seconds**	**AGV timer < 6 seconds**	**AGV timer > 10 seconds**	**AGV accelerates on designated path**	**AGV does not accelerate autonmously on designated path**	**AGV does not accelerate on designated path**	**Onboard computer controls emergency brake**
R18TC78	AGV interprets MDF & RNDF	V	I/V	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R18TC79	AGV recognizes stop sign approaching w/in 10 feet	V	I/V	V	I/V	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC80	AGV slows down	N/A	N/A	N/A	N/A	N/A	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC81	AGV comes to full stop w/in 1 meter of stop sign line	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC82	Timer begins upon stop	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	N/A	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC83	After 6 seconds, brakes are released	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	I/V	I/V	N/A	N/A	N/A	
R18TC84	AGV resumes moving on DARPA specified path	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	I/V	I/V	
R18TC78	AGV interprets MDF & RNDF	**yes**	**no**	**yes**	**no**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC79	AGV recognizes stop sign approaching w/in 10 feet	**yes**	**no**	**yes**	**no**	**yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC80	AGV slows down	N/A	N/A	N/A	N/A	N/A	**decelerating**	**accelerating**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC81	AGV detects error in slowing down																			
R18TC81	AGV comes to full stop w/in 1 meter of stop sign line	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**yes**	**yes**	**Too close to stop sign line**	**yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC82	Timer begins upon stop	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**yes**	N/A	**yes**	**Error w/ timer**	N/A	N/A	N/A	N/A	N/A	N/A	
R18TC83	AGV waits 6 seconds before proceeding	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**Proceed**	**Wait**	**Disqualified**	N/A	N/A	N/A	
R18TC84	AGV resumes moving on DARPA specified path	N/A	N/A	N/A	N/A	N/A	N/A	**yes**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**yes**	**Error w/ autonmous driving**	**Error w/ GPS route**	

VUC - V4R18 UC Diagrams



VUC - AGV Example

Subsystem Requirement: **V4R18: Braking System Use Case**

- *Description:*

  This use case covers the ability for the AGV to stop with in 1 meter of the stop line at a stop sign. **R18: AGV shall stop safely with in 1 meter of the stop sign intersection and proceed with out excessive delay (less than 10 seconds) according to intersection precedence rules.**

- *Actors and Goals:*
  - 1) AGV brakes
  - 2) Onboard computer sends instructions to other systems
  - 3) Linear Actuator controls brakes

- *Assumptions and Pre-Conditions:*
  - 1) Mission Data File and Route Network Definition File is uploaded
  - 2) Onboard computer recognizes stop sign approaching in 10 feet

VUC - AGV Example cont.

- *Basic Course:*
  - 1) Linear Actuator receives message from onboard computer to initiate brakes
  - 2) Linear Actuator pushes on brakes until AGV is at complete stop
  - 3) After 6 seconds brakes are released
  - 4) AGV resumes moving on designated path

- *Alternate Course:*
  - 2a) System detects error with the linear actuator
    - 1) Onboard computer ceases to accelerate AGV
    - 2) Emergency brake is activated
    - 3) AGV begins decelerating to 5 mph until stop sign line is w/in 1 meter
    - 4) Emergency brake initiated
    - 5) Repeat as necessary

- *Post Condition:*
  - AGV at complete stop for 10 seconds before continuing on route

TEST CASE

VUC - Results

- VUC method ensured AGV:
  - Stops w/in 1 meter prior to stop sign
  - resumes moving after 10 sec stop

- Neither of these were subsystem requirements
- Failure of either results in Disqualification

Table 4: AGV Vehicle Subsystem Requirment Test Case

Test Case ID	Scenario/ Condition (V4R18UC)	Onboard computer reads MDF and RNDF	Onboard computer interprets MDF and RNDF	Onboard computer controls linear actuator	Linear Actuator controls AGV brakes	Linear Actuator does not control brakes	Onboard computer communicates w/ TORC system	TORC system working	TORC system monitors and controls speed	AGV speed = zero
TC85	Onboard computer recognizes that stop sign is approaching in 10 feet	V	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TC86	Onboard computer sends message to initiate linear actuator initiating brakes	N/A	N/A	V	V	I/V	N/A	N/A	N/A	N/A
TC87	linear actuator pushes on brakes until AGV at complete stop	N/A	N/A	N/A	V	I/V	N/A	N/A	N/A	N/A
TC88	System detects error w/ the brake actuator	N/A	N/A	V	I/V	V	N/A	N/A	N/A	N/A
TC89	Onboard computer decreases AGV speed to zero	N/A	N/A	N/A	N/A	V	V	V	V	N/A
TC90	Onboard computer activates parking brake	N/A	N/A	N/A	N/A	N/A	V	V	V	V
TC85	Onboard computer recognizes that stop sign is approaching in 10 feet	Yes	displays first checkpoint	N/A	N/A	N/A	N/A	N/A	N/A	N/A
TC86	Onboard computer sends message to initiate linear actuator initiating brakes	Yes	displays first checkpoint	brake lights initiated	brake lights flash	N/A	N/A	N/A	N/A	N/A
TC87	linear actuator pushes on brakes until AGV comes to complete stop	N/A	N/A	N/A	brake lights flash	brake light do not flash	N/A	N/A	N/A	N/A
TC88	System detects error w/ the brake actuator	N/A	N/A	N/A	N/A	"Error w/ brakes"	N/A	N/A	N/A	N/A
TC89	Onboard computer decreases AGV speed to zero	N/A	N/A	N/A	N/A	N/A	yes	yes	yes	N/A
TC90	Onboard computer activates parking brake	N/A	N/A	N/A	N/A	N/A	yes	yes	yes	yes

Table 5: AGV Vehicle Subsystem Requirement VUC Test Case

		Test Cases																	
Test Case ID	Scenario (V4R18UC)	AGV has GPS coverage	AGV out of GPS coverage range	MDF & RNDF interpreted	MDF & RNDF NOT interpreted	Waypoint = stop sign approaching	AGV decelerates	AGV accelerates	AGV speed = zero	Stop sign line = 1 meter from AGV front bumper	Stop Sign line <1 meter from AGV front bumper	AGV timer starts	AGV timer does not start	AGV timer >/= 6 seconds < 10 seconds	AGV timer < 6 seconds	AGV timer > 10 seconds	AGV accelerates on designated path	AGV does not accelerate autonmously on designated path	AGV does not accelerate on designated path
V4R18TC28	Linear Actuator recieves message from onboard computer to initiate brakes	V	I/V	V	I/V	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC29	linear actuator pushes on brakes until AGV at complete stop	N/A	N/A	N/A	N/A	N/A	V	I/V	V	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC30	System detects error w/ the brake actuator	N/A	N/A	N/A	N/A	N/A	I/V	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC31	Onboard computer ceasess to accelerate AGV	N/A	N/A	N/A	N/A	N/A	I/V	V	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC32	Emergency brake activated	N/A	N/A	N/A	N/A	N/A	N/A	N/A	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC33	AGV begins accelerating to 5 mph until stop sign line is 1 meter away from vehicle bumper	V	V	V	I/V	V	I/V	V	N/A	V	I/V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC34	Emergency brake activated	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC35	After 6 seconds brakes released	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	I/V	V	I/V	I/V	N/A	N/A	N/A
V4R18TC36	AGV resumes moving on designated path	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	I/V	I/V
V4R18TC28	Linear Actuator recieves message from onboard computer to initiate brakes	yes	no	yes	no	yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC29	linear actuator pushes on brakes until AGV at complete stop	N/A	N/A	N/A	N/A	N/A	yes	no	yes	yes	no	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC30	System detects error w/ the brake actuator	N/A	N/A	N/A	N/A	N/A	no	yes	no	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC31	Onboard computer ceasess to accelerate AGV	N/A	N/A	N/A	N/A	N/A	yes	no	no	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC32	Emergency brake activated	N/A	N/A	N/A	N/A	N/A	N/A	N/A	yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC33	AGV begins accelerating to 5 mph until stop sign line is 1 meter away from vehicle bumper	yes	yes	yes	no	yes	no	yes	N/A	yes	no	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC34	Emergency brake activated	N/A	N/A	N/A	N/A	N/A	N/A	N/A	yes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
V4R18TC35	After 6 seconds brakes released	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	yes	no	proceed	wait	disqualified	N/A	N/A	N/A
V4R18TC36	AGV resumes moving on designated path	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	yes	no	no

VUC - Conclusion

- VUC method ensures
  - UC and Req are always linked
  - TC developed from UC
    - Customer gets what customer wants
- Decrease odds of missing req
- VUC adds TC, which increases costs
  - But cheaper than rework later in program
  - Helps avoid Program cancellation

Questions?

VUC - References

Bunz, U., & Maes, J. D. (1998). Learning excellence: Southwest Airlines' approach. *Managing Service Quality,* (http://bunz.comm.fsu.edu/southwest.pdf)

Daniels, J. & Bahill. T. (2004) The Hybrid Process That Combines Traditional Requirements and Use Cases [Electronic Version] *Wiley InterScience* (www.interscience.wiley.com)

DARPA Urban Challenge (http://www.darpa.mil/grandchallenge/overview.asp)

Global Security online (http://www.globalsecurity.org/military/systems/aircraft/a-12.htm)

Heumman, J. *Generative Test Cases from Use Cases* http://www.therartionaledge.com/content/jun01/m_cases_jh.htm

INCOSE Lean Systems Engineering Working Group "Lean Enablers for System Engineers" (http://cse.lmu.edu/Assets/Colleges+Schools/CSE/Mechanical+Engr/Lean_Enablers_for_SE_Version_1_01_.pdf.pdf)

Larman, C. *(2001). Applying UML & Patterns: An Intro to Object Oriented Analysis & Design & the Unified Process (*New Jersey: Prentice Hall)

Objective Engineering, INC. *Modeling Functional Requirements with Use Cases: Frequently Asked Questions* (2009, September), (http://www.oeng.com/pdf/UC-FAQ.pdf)

Wasson, C. (2006). *System Analysis, Design, and Development.* New Jersey: John Wile & Sons

Womack, J. & Jones. D (1996) *Lean Thinking*. New York: Simon and Shuster Press