Verification and Validation Report: Park'd

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1 Revision History

Table 1: Revision History

Date	Developer(s)	Change
March 2, 2023	Albert, Almen, David, Gary, Jonathan, Kabishan	Revision 0
April 3, 2023	Albert, Almen, David, Gary, Jonathan, Kabishan	Revision 1

2 Symbols, Abbreviations and Acronyms

symbol	**description**
T	Test
BE	Business Event
SRS	Software Requirements Specification
NFR	Non-Functional Requirement
FR	Functional Requirement
M	Modules
HTTP Request	A message sent by a client to initiate an action on the server through Hypertext Transfer Protocol

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Since this report is heavily based on validating the test cases we had derived in the Verification and Validation Plan, which was done well in advance of the implementation, we found that it would be inappropriate to test our system against these test cases if certain features were not yet implemented. Instead of failing a test case because the feature is not yet implemented, we have opted to mention Not Tested. These features will be ready in either Revision 1 or another revision, and can be tested then. However, if a feature was implemented and it satisfies the test case conditions, it will be denoted with PASS and FAIL otherwise.

NOTE: For all location detection related test cases, we acknowledge that location information from users is only as accurate as 5 metres. While this may seem like a huge error while walking or biking, this does not make much of a difference when driving a car, and results in similar driving instructions and navigation.

3 Functional Requirements Evaluation

Test Id	Driver Action	Expected Value	Actual Value	Result
BE1-FR1-T1	Driver launches the application	System prompts driver to allow location access	~~No prompt is given~~ A prompt is given	~~Not Tested~~ PASS
BE1-FR2-T1	Driver launches the application and allows location access	System displays a map of the driver's surroundings	System displays a map and is centered on the user's location ~~, but centred on a default point~~	~~Not Tested~~ PASS
BE1-FR3-T1	Driver launches the application and disables location access	System displays a map of the default surroundings	System displays a map and is centered on the default location	PASS
BE2-FR4-T1	N/A	System uses parking lot camera footage to survey status	System uses parking lot camera footage to survey status	PASS
BE2-FR5-T1	N/A	System recognizes and displays special parking spots	System does not display special parking spots	PASS
BE2-FR6-T1	N/A	System must allow parking spot locations to be determined	System allows admins to determine parking spot locations	PASS

BE2-FR7-T1	N/A	System prompts the driver for the lot they wish to navigate to	System displays available spaces arranged by lot	PASS
BE2-FR8-T1	Driver views a lot	System displays all available spaces in the lot	System displays all available spaces in the lot	PASS
BE3-FR9-T1	Driver filters by normal, accessible, and reserved spaces	System displays or hides the relevant spaces	System does not distinguish such spaces	~~Not Tested~~ FAIL
BE3-FR10-T1	N/A	System must display only normal spaces by default	System displays only spaces marked by the admin	PASS
BE3-FR11-T1	Driver selects a parking space	System recognizes the selection	System recognizes the selection	PASS

BE4-FR12-T1	Driver selects an available parking space	Driver must be shown directions from their location to the desired parking space	Driver is shown directions from their location to the desired parking space	PASS
BE4-FR13-T1	Driver selects the default parking space recommendation	Driver must be given directions to reach the recommended parking space	Driver is neither provided a recommendation nor provided directions to the parking space	~~Not Tested~~ FAIL
BE4-FR14-T1	N/A	The system must display directions to the default recommended parking space after $DEFAULT\_DELAY$ seconds	The system does not display navigation directions to the recommended space	~~Not Tested~~ FAIL
BE5-FR15-T1	Driver selects an unavailable parking space	System must inform the driver that they cannot park in a spot that is already occupied by another vehicle	System does not notify the driver of a spot's occupancy	~~Not Tested~~ FAIL
BE5-FR16-T1	Driver selects a reserved or accessibility parking space	System must inform the driver that they have tried to select a parking space that does not meet their needs	When the driver does not require reserved or accessibility parking, the system does not inform the driver when they select such a space	~~Not Tested~~ FAIL

BE6-FR17-T1	Driver's geographical location	As the driver commutes, the directions must be updated such that the parking space remains stationary and the driver's location is dynamic	Directions are not updated because geographical data collection from the driver's device is not yet implemented	~~Not Tested~~ PASS
BE6-FR18-T1	N/A	If the initial parking space selected by the driver is no longer available, the system must show another recommendation to the driver	Driver is not shown another parking recommendation if their initial choice becomes unavailable	~~Not Tested~~ FAIL
BE6-FR19-T1	N/A	Once the initial parking space is no longer available, the system must allow the driver pick another space from those that are available	Driver is able to select another parking space, but this is not due to the unavailability of the previous space	~~Not Tested~~ FAIL
BE6-FR20-T1	Driver routes to a parking spot that will be taken by someone else	System terminates the route and informs the driver	System returns to parking spot selection	PASS
BE6-FR21-T1	Driver routes to a parking spot and takes too long	System terminates the route and informs the driver	System returns to parking spot selection	PASS

BE6-FR22-T1	Driver has a estimation of their location on the map	System has a marker on the map representing the user's location	System has a marker on the map representing the user's location within an acceptable tolerance	PASS
BE6-FR23-T1	Driver has a estimation of their driving time	System displays a driving time estimation	System displays a driving time estimation within an acceptable tolerance	PASS
BE7-FR24-T1	Driver's geographical location	The system must inform the driver when they have reached their parking spot	Since the system is not yet configured to know when the driver has reached their location, no notification will be sent to the user	~~Not Tested~~ PASS
BE7-FR25-T1	Driver's geographical location	The parking space must change from available to unavailable	Parking space does change from available to unavailable, but this is due to constant machine learning surveillance, and not geographical information	~~Not Tested~~ PASS

BE7-FR26-T1	Driver reaches their destination	A survey for user feedback and dissatisfaction is presented	No survey is presented	~~Not Tested~~ FAIL
~~BE8-FR27-T1~~	~~Driver changes settings~~	~~The system changes accordingly to match the new settings~~	~~No changes occur~~	~~Not Tested~~
~~BE8-FR28-T1~~	~~Driver opens the settings page~~	~~System settings such as volume and sound adjustment, unit identification, vehicle details, and notification preferences are shown~~	~~Only unit identification is shown~~	~~FAIL~~
BE9-FR29-T1	Driver cancels their current route	The parking spot selection and path are removed	The system removes the path and returns to the spot selection page	PASS
BE9-FR30-T1	Driver cancels their current route	The system returns to the spot selection page	The system removes the path and returns to the spot selection page	PASS
BE10-FR31-T1	Admin logs in to the system	The system requests user credentials	The systems asks for a username and password	PASS

BE10-FR32-T1	Admin enters the wrong credentials	The system does not accept the credentials	The systems specifies the given credentials does not match any admin user	PASS
BE10-FR33-T1	Admin accesses occupancy map	A map over the parking lot showing which spots are occupied or not	A map showing the occupancy and controls for changing the layout	PASS
BE11-FR34-T1	Driver or admin selects a parking space	Analytics shows live occupancy of the parking lot over a period of time	Analytics shows occupancy of the parking lot at the given moment	PASS
BE11-FR35-T1	Driver or admin selects a parking space	Analytics should show twenty four hours of data for a parking space	Analytics shows twenty four hours of data for a parking space	PASS
BE12-FR36-T1	Admin changes the parking layout	Layout changes are saved	Layout changes are saved	PASS
BE12-FR37-T1	Admin changes a parking spot	Parking spot changes are saved	Parking spot changes are saved	PASS

4 Nonfunctional Requirements Evaluation

4.1 Look and Feel

Test Id	User Action	Expected Value	Actual Value	Result
NFR-LF1-T1	Development team sweeps through app by accessing all features they possibly can through buttons and other interfaces	All interface elements are deemed necessary	All interface elements are deemed necessary	PASS
NFR-LF1-T2	It is important to survey users on visual similarity to existing navigation apps after giving them *EXPLORATION_TIME* (especially for navigating and using the app) because it allows us to gauge how well our product compares to leading and well-reputed technologies in the market.	At least 80% of testers indicate that the app is visually similar to existing apps	N/A	PASS

4.2 Usability

Usability testing was done in part by having test users answer the Usability Survey Questions shown in the Verification and Validation plan. Responses were positive regarding the user-facing portion of the application, which is what the questions were focused on. Learnability was good overall owing to the simple interface.
The administrator console user interface was still in development at this time and users provided valuable feedback on important improvements to their experience. There was a disconnect between annotating the camera view and the map view which made it difficult to keep track of which two rectangles represented the same parking spot. The act of placing a spot on the map view was awkward, as it required four clicks at each corner. Improvements made from this feedback are detailed in Changes due to Testing.

Test Id	**User Action**	**Expected Value**	**Actual Value**	**Result**
NFR-UH1-T1	Users test all functions considered atomic and check that none take more than MAX_TAPS	All functions take less than MAX_TAPS taps	All functions take less than MAX_TAPS	PASS
NFR-UH2-T1	Users surveyed on the interface's similarity to existing navigation apps after given $EXPLORATION\_TIME$ to navigate and use the app	At least 80% of testers indicate that the interface is similar to existing apps	80% of testers indicate that the interface is similar to existing apps	~~Not Tested~~ PASS

NFR-UH3-T1	Users given *EXPLORATION_TIME* to find and navigate to an available spot	At least 80% of testers successfully find and navigate to an available spot	80% of testers successfully find and navigate to an available spot	~~Not Tested~~ PASS
NFR-UH4-T1	Developers go through all graphical assets used in the application and verify that each conform to any regulations set out by the Ontario Ministry of Transportation	All assets conform to the Ontario Ministry of Transportation regulations	All assets conform to the Ontario Ministry of Transportation regulations	PASS

4.3 Performance

Test Id	**User Action**	**Expected Value**	**Actual Value**	**Result**
NFR-PE1-T1	Monitor the system's FPS on different platforms during the app's normal operation by users	The system maintains a minimum of *MIN_FRAMERATE* at all times	The system maintains a minimum of *MIN_FRAMERATE* at all times	PASS
NFR-PE2-T1	User navigates to available parking spot	System should never navigate the user off the road	System does not navigate users off the road	PASS

NFR-PE3-T1	User navigates to available parking spot	System should never navigate the user to park at a restricted or reserved area or spot	System does not navigate the user to park at a restricted or reserved area or spot	PASS
NFR-PE4-T1	User finds and navigates to an available parking spot while the back-end service is disabled	The system displays the most recent recommended available parking spot	System displays incorrect parking spot status	FAIL
NFR-PE5-T1	10 users request different parking lot information at the same time	Parking lot information requested by 10 different users shall be processed and sent to the users devices	Correct parking lot information that is requested is provided to each individual user	PASS
NFR-PE6-T1	User is able to see at least 2 parking lot layouts in 6 months from the launch of the application and is launched in a vehicle	At least 2 parking lot layout in 6 months and is launched in a vehicle	2 parking lot layout in 6 months and is launched in a vehicle	~~Not Tested~~ PASS

4.4 Operational and Environment

Test Id	User Action	Expected Value	Actual Value	Result
NFR-OE1-T1	User inputs an address, selects a parking space, and follows the directions given by the parking space	Accurate directions to the designated address is given to the user and the user is able to successfully drive and locate the parking space	Accurate directions to the designated address is given to the user and the user is able to successfully drive and locate the parking space	~~Not Tested~~ PASS
NFR-OE2-T1	N/A	New update is given every month	Application was updated every month	~~Not Tested~~ PASS
NFR-MA1-T1	Developer takes the camera offline	The application prompts the User that the camera is offline and that the application is still functional	No such prompt appears	~~Not Tested~~ PASS
NFR-MA2-T1	Users are given the instructions on the help section of the application and fills a survey indicating the satisfaction with the information given	80% of the results should be satisfied with the instructs and contacts given	No help section	~~Not Tested~~ FAIL

4.5 Security

Test Id	User Action	Expected Value	Actual Value	Result
NFR-SR1-T1	Admin logins with a valid username and password for the parking lot they own/manage	Redirection to the admin console with proper parking lot data of their parking lot and administrative controls	Redirected to the admin console with proper parking lot data of their parking lot and administrative controls	PASS
NFR-SR1-T2	Admin attempts to login with an invalid username and password for the parking lot they own/manage	Prompt indicating that the login was unsuccessful	Prompt indicating that the login was unsuccessful	PASS
NFR-SR1-T3	Driver selects a parking lot on the application	No analytics and parking lot data is shown	No analytics and parking lot data is shown	PASS

Test Id	User Action	Expected Value	Actual Value	Result
NFR-SR2-T1	Admin logins with a valid username and password for the parking lot they own/manage	Edit function is enabled allowing the Administrator to edit their parking lot	Edit function is enabled allowing the Administrator to edit their parking lot	PASS
NFR-SR2-T2	Driver selects a parking lot on the application	Edit function is not shown	Edit function is not shown	PASS
NFR-SR3-T1	Admin logs in to the admin console and searches for a parking lot that they do not own	Edit functionality disabled and analytics are not displayed.	Admin cannot edit other people's parking lots	~~Not Tested~~ PASS

Test Id	User Action	Expected Value	Actual Value	Result
NFR-SR4-T1	Developers log into the database on the server and changes the status of an empty parking lot entry in the database to full and refresh the databse	The database reverts the status of the parking lot entry to the correct one, indiciating it is empty	Status of parking spot reverts to its actual status	~~Not Tested~~ PASS
NFR-SR5-T1	Admin logs in to the admin console, edits and saves the parking lot layout, and disconnects the system from the internet	Parking lot layout layout is cached as a JSON file and a prompt is indicating that the unsaved layout is cached and the location.	No prompt about unsaved layouts	~~Not Tested~~ FAIL

Test Id	User Action	Expected Value	Actual Value	Result
NFR-SR6-T1	User edit parking lot layout information and do not submit changes until the timer exceeds ATTEMPT UPLOAD TIME	Layout information should be saved and a prompt window should show up indicate the action is completed successfully	The layout information is not saved	Fail
NFR-SR7-T1	Check the backup log file and see if it is updated daily	The log file should contains the record for each daily updates	No changes occur	Fail
NFR-SR8-T1	User creates multiple different parking lot layout and examine the returned JSON	The data format should be the same for each parking lots	The JSON format is consistent with each parking lots	PASS
NFR-SR9-T1	User logs in and check the availability of certain parking lots	Each spot should have at max 1 special property	Each spot can have at most 1 special property	~~Not Tested~~ PASS

NFR-SR10-T1	User attempt to add a parking spot to the database when it reaches maximum capacity	A window should be prompted indicates the action is illegal	No prompt are shown	~~Not Tested~~ FAIL
NFR-SR11-T1	User attempt to add parking lot and save the layout to database	A window should be prompted indicates the action succeed	User is prompted that the action was successful	~~FAIL~~ PASS
NFR-SR12-T1	User request navigation from current location to destination	The correct navigation path should be shown	Paths are shown on the main page	PASS
NFR-SR13-T1	User request navigation for a destination that is impossible to reach with vehicles	A window should be prompted indicates the action is not permitted	The navigation failed with a prompt message indicates the reason	PASS

NFR-SR14-T1	User request navigation for a destination	User should be prompted for access for location data	User is prompted for allowing the use of their location data	~~Not Tested~~ PASS

4.6 Legal

Test Id	User Action	Expected Value	Actual Value	Result
NFR-LR1-T1	The user is in navigation mode and while moving, the user attempt to interact with the website	notification window should pop out, informing the driver to follow the regulations	Window pops out	PASS

5 Comparison to Existing Implementation

In our SRS, we had discussed two applications, namely ParKam App and Spot Sensor, that are already on the market and perform similar features to our implementation.

ParKam is closed source, therefore a white box comparison is impossible to perform. In addition, it is infeasible to perform a direct feature comparison between our solution and ParKam, because their solution is not offered in the North American market. Attempting to use their product would entail a lengthy application process that may or may not succeed. According to their website (https://parkam.com) and in some of their YouTube videos, their product seems to be much more polished, robust and feature-packed compared to our current implementation. For example, in addition to navigation and availability, which our solution supports, they also detect illegal parking. They also perform a variety of edge case testing, such as not double counting parking spaces when the outline of a parking lot is drawn twice on top of the same space.

The other application, Spot Sensor, uses ultrasonic signal sending hardware to detect parking spaces. Since this implementation is widely used among various parking spaces in Toronto, we can compare how well the sensor detects the parking's availability compared to our machine learning model, which on the other hand, is a pure software solution. Needless to say, Spot Sensor, does not provide any other functionality, such as navigation, therefore, this solution can only be used to evaluate our parking detection algorithm.

6 Unit Testing

The detail plans regarding the following tests are outlined in the VnV plan document

Tested Module	User Action	Expected Value	Actual Value	Result
Database module Test 6.2.1.1	User saved json object includes the annotation coordinate under the "CamCoords" key.	Response body object with annotation	The response body object contains the previously saved CamCoords data	PASS
Database module Test 6.2.1.2	User saved json object includes the annotation coordinate under the "MapCoords" key.	Response body object with annotation	The response body object contains the previously saved MapCoords data	PASS
Database module Test 6.2.1.3	User entered the Youtube link.	Response body object with annotation	The response body object contains the previously saved Youtube link data.	PASS
Database module Test 6.2.1.4	User request to view a particular parking.	The current_input key should be set to the Youtube URL of the parking lot user wish to view	The string URL under the current input key is set to be Youtube URL for the corresponding parking lot	PASS
Database module Test 6.2.1.5	User request to view a particular parking.	The current_coordinate key should be set to the annotation values of the parking lot user wish to view	The annotation values under the current_coordinate key is set to be the data for the corresponding parking lot	PASS
Parking stats Module Test 6.2.2.1	User append the analytic 1 hour data to the database	The up to date analytic data with a testing parking lot	The returned analytic data include the recently appended data of the parking lot	PASS

Tested Module	User Action	Expected Value	Actual Value	Result
View Module - Test 6.2.3.1	User enters a valid email and password for the parking lot	Redirection to Administrative Console	Redirection to Administrative Console	PASS
View Module - Test 6.2.3.2	User enters an invalid email and password for the parking lot	Error message pops up	An error message "Invalid email. Try again." pops up	PASS
View Module - Test 6.2.3.3	User enters a non-existent email and password for the parking lot	Error message pops up	An error message "User does not exist. Try again." pops up	PASS
View Module - Test 6.2.3.4	User does not enter an input	Error message pops up	An error message "Internal error. Input a correct username and password and try again." pops up	PASS
View Module - Test 6.2.3.5	User does not enter an input	Error message pops up	An error message "Wrong password. Try again." pops up	PASS
View Module - Test 6.2.3.6	User clicks button to user mode	Redirection to User Mode	Redirection to User Mode	PASS
View Module - Test 6.2.3.7	Admin clicks the button to open the sidebar	Sidebar opens with all the admin features	Sidebar opens with all the admin features	PASS
View Module - Test 6.2.3.8	Admin clicks the logout button	Admin is logged out and is redirected to the login page	Admin is logged out and is redirected to the login page	PASS

7 Changes Due to Testing

All of the these changes were made due to user validation testing, where one of our group members had their parent use our product for surveying their parking lot. A wide variety of changes were implemented in Revision 1, but in future revisions, we will tackle NFR-PE4-T1 and NFR-SR11-T1.

1. BE11-FR35-T1
   The user mentioned that it would easier to view trends in occupancy and availability, so we added dropdown menu beside Analytics to allow Admins to see trends over a specified period of time.

2. BE10-FR33-T1
   Add back-end service to allow the front-end to modify coordinates of boxes that define the parking lot layout.

3. BE10-FR33-T1
   Add back-end service to allow the front-end to modify the status of spots in the parking lot.

4. NFR-PE4-T1
   Add temporary storage for front-end to modify and pull status of parking spot status in the case that it loses connection with the back-end services.

5. NFR-SR6-T1
   Add back-end service to allow the front-end to modify coordinates of boxes that define the parking lot layout.

6. NFR-SR7-T1
   Add back-end service to regularly back up the parking lot layout data daily.

7. NFR-SR11-T1
   The user wanted more responsiveness from the system. For example, getting validation if their action was performed correctly. As such, we added a pop-up modal or message to indicate to the user that the action was successful.

7.1 Changes from usability testing

Since there were no instructions for the user-facing portion of Park'd, those were added in an About page.
The administrator console saw large updates based on user feedback. The camera view and map view were moved side by side. When placing a box for a parking space in the camera view, a corresponding box is now automatically placed in the map view, rather than having the user place both manually. Deletion is now done from the camera view, affecting both boxes automatically. In addition, when mousing over a box in the camera view, the corresponding box in the map view is now highlighted.

8 Automated Testing

Automated API testing is used for python back-end server and test suits were built on postman. Using the automated testing features in Postman, each APIs were tested as following.

Test Id	**Input**	**Expected Value**	**Actual Value**	**Result**
API-T1-avail	{'park_id': 0 }	response: {'timestamp': 16278900565, 'availability': [True, True, False, False, True]}	{'timestamp': 16278900565, 'availability': [True, True, False, False, True]}	PASS
API-T1-save	{'park_id': 0 }	response: {'timestamp': 16278900565, 'Res': True}	{'timestamp': 16278900565, 'Res': True}	PASS
API-T1-snap	{'park_id': 0}	response: {'timestamp': 16278900565, 'Res': snap_shot_0.jpg}	{'timestamp': 16278900565, 'Res':snap_shot_0.jpg}	PASS

9 Trace to Requirements

The traceability of test cases to requirements can be referred to in the VNV Plan Document.

10 Trace to Modules

Table 2: Traceability Matrix for Test Cases and Modules - Part 1

		Modules												
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
Test Cases	BE1-FR1-T1								X	X				
	BE1-FR2-T1								X	X				
	BE1-FR3-T1								X	X				
	BE2-FR4-T1		X									X		
	BE2-FR5-T1			X	X	X	X	X	X			X		
	BE2-FR6-T1			X	X	X	X	X	X					
	BE2-FR7-T1										X			X
	BE2-FR8-T1			X										
	BE3-FR9-T1						X	X						X
	BE3-FR10-T1					X								
	BE4-FR11-T1						X	X						X
	BE4-FR12-T1									X				
	BE4-FR13-T1					X								X
	BE4-FR14-T1									X				

Table 3: Traceability Matrix for Test Cases and Modules - Part 2

		Modules												
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
Test Cases	BE5-FR15-T1							X						X
	BE5-FR16-T1							X						X
	BE6-FR17-T1									X				
	BE6-FR18-T1					X		X				X		
	BE6-FR19-T1													X
	BE7-FR20-T1									X				
	BE7-FR21-T1									X				
	BE7-FR22-T1									X				
	BE7-FR23-T1									X				
	BE7-FR24-T1									X				
	BE7-FR25-T1							X				X		
	BE7-FR26-T1													X
	BE8-FR27-T1													X
	BE8-FR28-T1													X
	BE9-FR29-T1									X				X
	BE9-FR30-T1									X				

Table 4: Traceability Matrix for Test Cases and Modules - Part 3

		Modules												
		M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13
Test Cases	BE10-FR31-T1			X					X					
	BE10-FR32-T1			X					X					
	BE10-FR33-T1				X				X					
	BE11-FR34-T1								X		X			
	BE11-FR36-T1				X				X					
	BE11-FR37-T1				X				X					

11 Code Coverage Metrics

From the VnV plan, we targeted at least 80% code coverage on Python code with Coverage.py and on UI code with Istanbul. We reached 100% and 90% respectively.

12 Appendix

12.1 Symbolic Parameters

$MAX\_TAPS = 2$
$MIN\_FRAMERATE = 15$
$DEFAULT\_DELAY = 10$
$EXPLORATION\_TIME = 5$ minutes

12.2 Reflection

The information in this section will be used to evaluate the team members on the graduate attribute of Reflection. Please answer the following question:

1. In what ways was the Verification and Validation (VnV) Plan different from the activities that were actually conducted for VnV? If there were differences, what changes required the modification in the plan? Why did these changes occur? Would you be able to anticipate these changes in future projects? If there weren't any differences, how was your team able to clearly predict a feasible amount of effort and the right tasks needed to build the evidence that demonstrates the required quality? (It is expected that most teams will have had to deviate from their original VnV Plan.)

The main differences are as follows:

1. Some functional requirements from the first version of the VnV Plan were not tested because the functionality they encompassed was dropped from the Revision 0 Demo, due to time constraints.
   Changes like these can be anticipated to an extent in future projects because group members can often approximately predict the time needed to implement a given feature or function. However, given the large number of requirements, and the possibility of unexpected issues such as code incompatibility, this is not always the case. Ultimately, designers can only guess at what will be feasible to implement by the next deadline. In our future careers as engineers, we should couple our anticipation of changes with the use of Gantt charts to provide slack time, in case a change that requires five days ends up requiring two

weeks. We are also better equipped to anticipate changes because now we know to do prior research of the technologies used, which will inform our estimates of work effort.

Therefore, there should always be some leeway in which requirements are tested and which ones are left for later. By highlighting which requirements are of high priority, and by only using such a classification sparingly, we can ensure the most important functionality of an application is always verified and validated. A hierarchy of requirements always exists, but writing it down can help designers prioritize and delegate tasks appropriately.