Gamepads to improve performance: a study of gaming controller integration in military vehicle control systems

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Abstract

To determine if military engineering design could consider the integration of gaming controllers, an experiment was conducted to compare a fixed-handle joystick (configured to match the current M113AS4 turret controller) against an Xbox One controller (gamepad) in a stationary firing range simulation. 135 participants were tested in the simulation with each controller. In order to explain differences in participant performance, data on their gaming history and perceived workload for each controller was also collected. The majority of participants (70.37 %) preferred gamepad-oriented devices. Far more participants had previously experienced gamepad-based gaming compared to using a joystick (92.59 % against 42.22 %). Additionally, the majority of participants preferred the first person shooter gaming genre (52.59 %). Lastly, almost all participants (97.04 %) were faster in the simulation with the gamepad than the joystick (mean completion times: 47.67 s against 65.70 s). The research findings support the recommendation that further research be conducted into practical application, cost effectiveness and feasibility of gaming controller integration into military vehicle control systems.

1 Introduction

The Australian Army Armoured Personnel Carrier, the M113AS4, is capable of transporting up to 10 soldiers as well as the driver and crew commander (turret operator). The purpose of the M113AS4 is to provide protected mobility and fire support to infantry soldiers in combat situations. With a single turret-mounted weapon system (12.7 mm heavy machine gun) controlled by a bespoke fixed-handle joystick, the soldiers inside the M113AS4 depend heavily on the crew commander to be able to engage enemy targets in stationary and mobile situations. The initial scenario considered by this research report was the advance-in-contact tactical manoeuvre, during which M113AS4s transport infantry forward to positions very near or directly adjacent to enemy defensive positions in order to assault them. The M113AS4s provide coordinated fire as they advance, but as they do so, they are at risk of receiving defensive fire from the enemy. If a crew commander were incapacitated — with the turret left intact — one of the soldiers in the rear of the vehicle would be required to operate the turret to maintain fire on the enemy. This would require the new operator to be already trained in the turret control system or to be able to adapt to it immediately under pressure. It is in this scenario that the current engineering solution is restrictive, as the turret controller is modelled similarly to a gaming joystick but with several major differences that are not immediately intuitive.

Figure 1: M113AS4 providing fire support to dismounted infantry

1.1 An unfamiliar turret controller

The M113AS4 turret controller does not operate like a standard joystick; a thumb control on the top of the handle is manipulated to rotate the turret and depress or elevate the weapon system. The palm switch (see Figure 2) must also be depressed for the turret to respond to

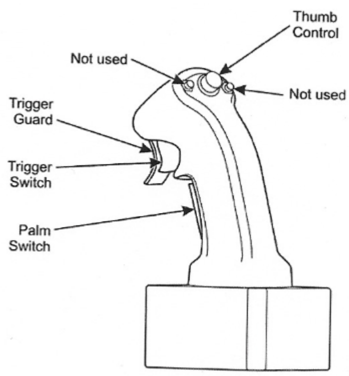

Figure 2: M113AS4 turret controller (MM, 2014)

any input from the controller, including firing the weapon system. The turret controller in Figure 2 would be unfamiliar to a soldier that has prior experience with gaming joysticks: the handle is fixed and despite the obvious trigger to fire, it is not immediately apparent what to do with the thumb control, palm switch and other buttons that are not programmed. The fixed handle serves to stabilise the crew commander as the vehicle moves over rough terrain, which is a practical feature of the current design. In these situations, the palm switch acts as a safety measure to prevent the crew commander causing unwanted turret movement. Nonetheless, without prior exposure to this exact system, it would be unlikely that an unfamiliar or untrained soldier could adapt and effectively operate the system, especially in the heat of battle.

1.2 Proposing gamepad integration

Although the above scenario was the catalyst for this research, it cannot be considered in isolation. Predominantly, the crew commanders of the Australian Army M113AS4s are not incapacitated on the job and unit commanders do not expect unqualified soldiers to occupy the turrets of the vehicles transporting them. For a control system change to be justified, the new system should be sufficiently better than the old one, but not just ergonomically for untrained personnel. By that rationale, any replacement of the turret controller should:

- exploit systems that the user may already be familiar with or can immediately understand,
- reduce training burden,
- be just as functional and ergonomic within the turret, and
- provide for additional industry-supported training and maintenance solutions.

A turret controller replacement should reduce training time and associated costs, enable soldiers to conduct familiarisation training outside of the turret through realistic simulation and still provide a high level of ergonomic satisfaction (Alexander, Brunye, Sidman, & Weil, 2005; Ibanez, 2016).

This research focusses on testing such a replacement modelled off the Xbox One controller (gamepad) shown in Figure 3, one of many gaming devices designed specifically to allow users to control what is in front of them without having to think about the controls (Cummings, 2006; Natapov, Castellucci, & MacKenzie, 2009). Since 2005, Bond University has collected statistics on video gaming in Australia every two to three years. In their research, sample sizes for data collection typically exceeded 3,000 participants per study. For this report, the most significant data from the latest Bond research is that 93 % of households in Australia have at least one device for gaming and 60 % of households use gaming consoles, of which the primary interface is a gamepad (Brand, Todhunter, & Jervis, 2017). The average age of the Australian gamer is 34 years old (Brand, Todhunter, & Jervis, 2017), while the Australian Bureau of Statistics (ABS) places the average age of Australian Defence Force (ADF) members at 36 years old (ABS, 2011). When members over 50 years old are removed from the ABS data pool (as it is extremely rare to have an M113AS4 crew commander over 50 years of age), the average age of ADF members reduces to 32 years (ABS, 2011). These statistics provided some background as to what could be expected from ADF participants, assuming they reflected the wider Australian population.

Figure 3: Xbox One controller

1.3 Existing research

Research comparing a gamepad to a fixed-handle joystick is not available for analysis as the latter configuration is not widely replicated. However, studies do exist that are able to put such a comparison into broader context. Rosser et al. (2007) found that surgeons conducting simulated laparascopic surgery tasks (minimally invasive surgery that involves the use of a remote console to control cameras and surgical equipment) showed significant correlation between video game experience and skill: experienced gamers had 32 % fewer errors, were 24 % faster and 26 % better overall. They concluded that introducing video games into training could assist surgeons in screen-mediated applications. Rupp et al. (2013) compared the use of a gamepad and a joystick in an aerial tracking assignment, simulating several tasks conducted during the flight of unpiloted vehicles. This research determined that users performed better in the assignment with the gamepad than the joystick, showing higher accuracy and fewer errors. Additionally, those users who reported previous experience with a gamepad also performed better with it.

Review of existent literature found that researchers who compared gamepads with joysticks generally expected better performance from participants with the gamepad, despite results not always supporting this. For example, Fund (2015) found that in a driving simulation, there was no significant difference between participants' performance with a gamepad compared to a joystick. Nevertheless, there were several conclusions, such as those by Yurko et al. (2010), Rosser et al. (2007) and Alexander et al. (2005), that guided the overall structure of the research experiment and provided for the analysis of variables not previously considered (such as frequency of gaming and preference of system).

Three shortfalls of the existing research became apparent. Firstly, none of the relevant research concentrates on military participants. This provides a potential restriction for how applicable it could be as studies on civilians cannot always be applied to military contexts, particularly to that of a turret control system. Secondly, none of the research makes a direct comparison between the two control systems covered in this paper; as mentioned above, the use of fixed-handle joysticks is not widely replicated in gaming. Thirdly, with the exception of the general data collection in the Digital Australia Reports (Brand, Todhunter & Jervis, 2017; Brand, & Todhunter, 2015), the existing research relevant to this field has been conducted with relatively few participants at a time. Of those supporting studies that involved experiment, participant numbers were as follows:

- Fund (2015): 51,
- Yurko et al. (2010): 28, and
- Rosser et al. (2007): 33.

To that end, this research paper sought to address the above issues and attempted to capture as much relevant data from military participants as possible, collecting data from 135 personnel.

2 Experiment

It was assessed that user data from a simulation task in isolation would be insufficient in supporting robust conclusions. Therefore, the experiment was developed as three constituent components. These were:

- a pre-simulation questionnaire (to gather background data on participants),
- a stationary M113AS4 firing range simulation (to assess participants' performance with the joystick and gamepad), and
- a post-simulation raw NASA Task Load Index (TLX) (to assess participant workload with each controller) (NASA, 2017).

The experiment was designed to correlate relevant background data with participant performance and assessed workload in the simulation. Each participant took an average of five to ten minutes to complete all components of the experiment (including breaks) and participation was entirely voluntary with no rewards offered for involvement.

2.1 Participants

The participants in the research study were ADF members from three separate ADF units, the Australian Defence Force Academy (ADFA), the Australian Federation Guard (AFG) and the Royal Military College - Duntroon (RMC-D). Prior to participation, members were given verbal and written information about the research and each participant provided written consent for the use of their information. Participants were informed that names would be removed from any published documentation. In total, there were 135 participants with a demographic representation as per Figure 4. As both ADFA and RMC-D are

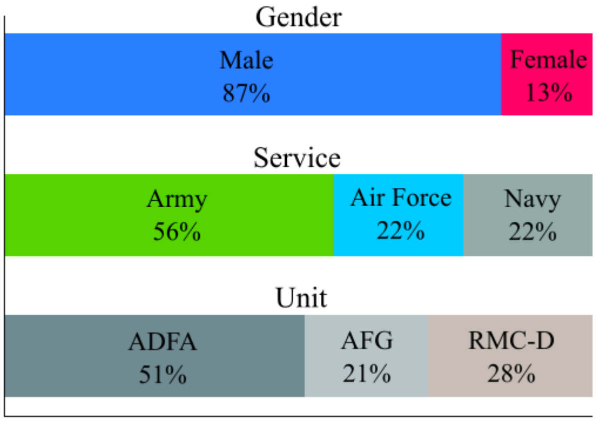

Figure 4: Demographics of participants in research study

training institutions, the mean ages and average time in service for these units was lower than AFG, from which participants were all qualified personnel of service lengths up to 16 years. There is also higher representation from Army than Air Force or Navy as RMC-D is an Army-only institution, while ADFA and AFG are tri-service. The similarities and differences between the units are discussed further in Section 3.5.

2.2 Pre-simulation questionnaire

Prior to the simulation and the raw NASA TLX, participants completed a short questionnaire. The questionnaire collected basic military demographic information as per Figure 4 and also asked specific questions about gaming experience with particular systems, game genres and interfaces. For reference, the questionnaire is located at Appendix A. The purpose of the questionnaire was to extract relevant information from the participants that could be correlated to simulation performance and associated workload scores. Additionally, it was expected that some findings in associated research, such as that by Yurko et al. (2010) and Rosser et al. (2007), would be replicated. Namely, it was expected that there would be a noticeable difference in how familiar participants were with the gamepad compared to the joystick. It was also expected that those participants that were identified to play games more frequently and for longer durations would outperform those that did not. Broadly, these findings were well supported and are discussed in Sections 3.3 and 3.4.

2.3 Simulation

The simulation was developed using the free Unity 3d Game Engine (Unity, 2017). A stationary M113AS4 firing range was considered an appropriate method to compare the two controller types. Additional variables such as vehicle movement, tactics or the ability to receive damage from targets that return fire were not considered. The goal was to analyse participant performance with each controller type in a simple target engagement exercise. The simulation was displayed on either a large television or a projector connected to a laptop running the Unity software. Participants used a wired Microsoft Sidewinder joystick (modified so that the handle was fixed as per the M113AS4 turret control system) and a wireless Xbox One controller to engage targets. The gamepad was not fixed and participants could hold it where they wanted to. Although the joystick and the gamepad had different button layouts, the speed at which the turret could move and fire was consistent across both controllers.

2.3.1 Conduct

Participants were briefed that their task in the simulation was simply to hit all of the targets presented. They were also informed how to use each controller and told that the number of rounds they fired or where they hit each target did not affect their results; the results were time-based only. Participants were then presented with an information screen in the simulation detailing which controller to use and how to start. As the simulation was designed to test performance between the two control systems under identical conditions, the same simulation was run for each participant with both the joystick and the gamepad, one after the other. To account for any participants anticipating the simulation with the second controller they used, the order in which participants used the controllers was split. A total of 81 participants conducted the simulation with the joystick first and 54 conducted it with the gamepad first. The disproportionate representation here is due to timing constraints and limited volunteers for the gamepad-first element of the data collection. Variations between these two groups is discussed in Section 3.1.

Upon starting the simulation, participants were presented with the first round of six blue targets as per Figure 5. Once they had successfully engaged all targets, the simulation paused for five seconds before the second round was presented: six yellow targets with a diameter of 75 % of the blue targets. After the second round completion, participants were presented with the final round: six red targets with a diameter of 50 % of the blue targets.

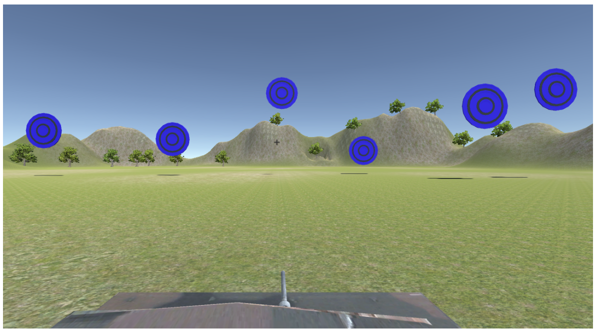

Figure 5: The first round of simulation targets

The decreasing size of the targets presented the challenge of using fine motor control skills with each controller and the comparison of the results of each round is discussed in Section 3.1. Once a participant had completed all rounds with the first controller, they repeated the process with the second controller. Upon completion of the final round with the second controller, participants were presented with the times taken for each round for each controller as per the example in Figure 6. Participant round speeds were recorded and collated with the other data provided by that participant.

Figure 6: Example participant results

2.3.2 Goal

The goal in the simulation for the participant was to engage all of the targets available on the screen as quickly as possible. There were two goals for the simulation in support of this research report:

- to highlight the performance differences between the joystick and the gamepad, and
- to find correlations between performance and participant preference or experience with a specific gaming system or genre.

2.3.3 Simulation controls

The palm switch could not be replicated on the gaming joystick and so it was not replicated on the gamepad either. With that exception, the joystick controls were configured as per the current M113AS4 turret controller. The gamepad turret rotation and weapon elevation was programmed to the gamepad's left thumbstick and the right trigger was used as the 'fire' button. In both controllers, pushing forward on the thumb control (on the joystick) or the left thumbstick (on the gamepad) would elevate the weapon system and pulling back would depress it.

On the M113AS4, the turret is sensitive to oblique movements of the thumb control. A crew commander intending to rotate the turret while maintaining a particular weapon elevation can very easily provide elevation input due to this oblique sensitivity. Therefore, consideration was given to the gamepad controls isolating turret rotation to the left thumbstick and weapon elevation to the right thumbstick, removing this inconvenience. However, from initial testing prior to any data collection, these controls lacked a 'natural feel'. It was instinctive across several users to still try to use the left thumbstick for all movement. Thus, the configuration of all movement being handled by the left thumbstick was selected, with the right hand being responsible for firing the weapon only. Although it did not solve the inadvertent oblique movement issue, it still resulted in a far more natural response in initial users prior to data collection. This satisfied the requirement to exploit a system that the user may already be used to, as mentioned in Section 1.2.

During data collection, all participants had access to visual aids for how each control system worked. For the gamepad, no participant experienced issues in identifying how to use it or were confused by the button layout. Contrastingly, despite the visual aids and briefing on how each system worked, several participants did not initially understand that the joystick was fixed and came close to breaking it as they attempted to force the handle forwards or backwards. This served to highlight the uncertainty an unfamiliar soldier would experience when occupying the turret for the first time, even after being told how the controller worked.

2.4 Raw NASA TLX

After the simulation, participants immediately completed a raw NASA TLX (Appendix B). The TLX uses six subscales to estimate user workload during a task (Sharek & Wiebe, 2014). Workload is simply defined here as how much work is required for a task. The definition itself is not important; 'the subscale ratings that are weighted according to their subjective importance to raters' is what matters (NASA, 2017, p. 2). Typically, the form at Appendix B is accompanied by a second form in which users apply weightings to each subscale through the use of 15 different subscale pairings (performance against effort, performance against frustration, etc.). This additional task can be confusing and requires more time and input by participants. It was assessed that the simplicity of the tasks and relatively short time to complete the surveys and simulation would be contributing factors to maximising the number of participants that data could be collected from. Compared to the standard TLX, a raw TLX — taking the average of all subscales without weighting — can be conducted. Byers et al. (1989) found that the raw TLX yielded equally sensitive results to the standard approach and Hendy et al. (1993) found it to be even more sensitive. Thus, the raw TLX was selected to reduce confusion and time taken by participants. The ratings given to each subscale by participants were equally weighted; however, it should be noted that 19 participants gave zero scores for both controllers for physical demand, showing that weighting could have been applied.

3 Findings

This research report extracts several key findings from the experiment and data collected:

- regardless of which controller was used first, participants completed the simulation faster with the gamepad than with the joystick,
- participants recorded lower workload scores for the gamepad than the joystick,
- participants showed a far higher experience level with gamepads and game types that have similar control layouts to that used in the simulation,
- participants with higher experience levels for each controller only showed higher performance if that controller was the gamepad but not the joystick, and
- participant performance levels varied minimally between units despite relative age and service length differences.

The raw data from the experiment can be found at Appendix C.

3.1 Simulation completion speed

Overwhelmingly, participants were faster in the simulation with the gamepad than with the joystick. Mean total times taken were 65.70 s for the joystick and 47.67 s for the gamepad (27.44 % faster). Figure 7 (over page) shows participant total time taken with the gamepad plotted against total time taken with the joystick. The line of 'y=x' from the origin indicates values that would correspond to equal total times for each controller. Data that lies above this line indicates participants that took longer with the joystick than the gamepad (and vice versa). As mentioned above, a total of 81 participants conducted the simulation with the joystick first and 54 with the gamepad first. Regardless of which controller was used first, the vast majority of participants in each group completed the simulation faster with the gamepad than with the joystick (97.04 %). This is further evident when a histogram is taken for the total joystick time minus the total gamepad

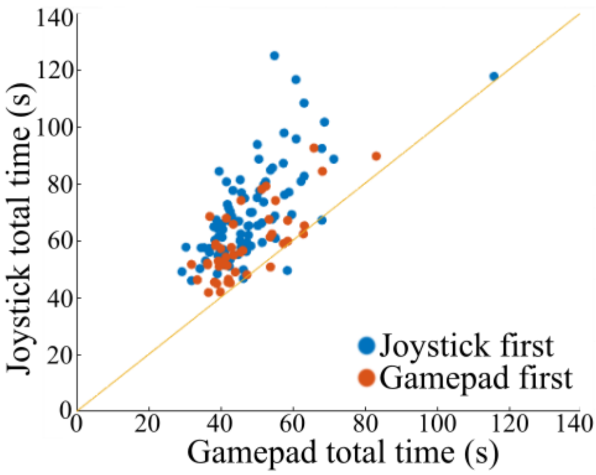

Figure 7: Gamepad total time vs. joystick total time

time. As can be seen in Figure 8, participants were most commonly between 10 s and 20 s faster with the gamepad. In fact, the mean

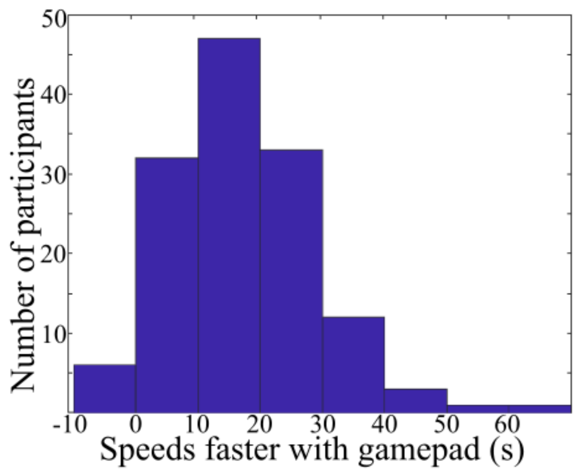

Figure 8: Histogram of total joystick time minus total gamepad time

difference for participants was 18.03 s in favour of the gamepad. The mean relative time differences between the controllers were calculated for each level of difficulty in the simulation as per Table 1:

Table 1: Mean relative time difference between controllers

Round	Faster controller	Amount (%)
Blue (easy)	Gamepad	21.72
Yellow (medium)	Gamepad	21.87
Red (hard)	Gamepad	28.93

In every target round, participants were faster with the gamepad than with the joystick. As targets decreased in surface area, participants also showed better relative performance with the gamepad. This indicates a level of fine motor control that participants were able to exercise with the gamepad that they weren't able to exercise with the joystick.

3.2 Workload scores for each controller

Similar to Figure 7, participant average workloads are plotted in Figure 9. As mentioned in Section 2.4, equal weightings were applied to each TLX subscale and so Figure 9 shows the means of the scores recorded by participants for each controller. Higher mean scores are an indication

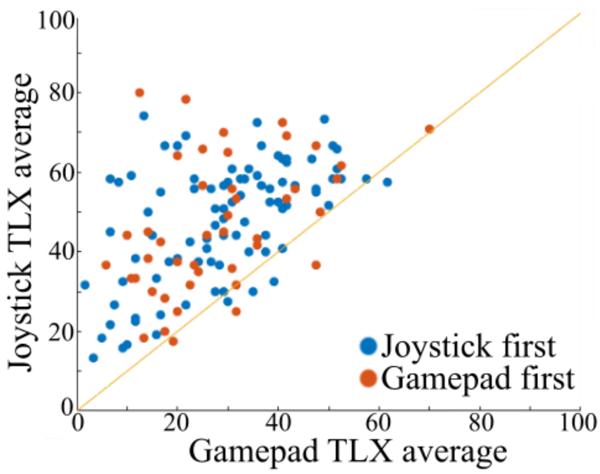

Figure 9: Gamepad TLX average vs. joystick TLX average

that participants found the control system hard to use or unnecessarily complicated in general. Again, the 'y=x' line in Figure 9 indicates values that would correspond to equal workload scores for each controller. As can be seen in Figures 9 and 10, the majority of participants recorded higher workloads for the joystick than the gamepad. Most commonly, participants scored the gamepad between 10 and 20 points lower than

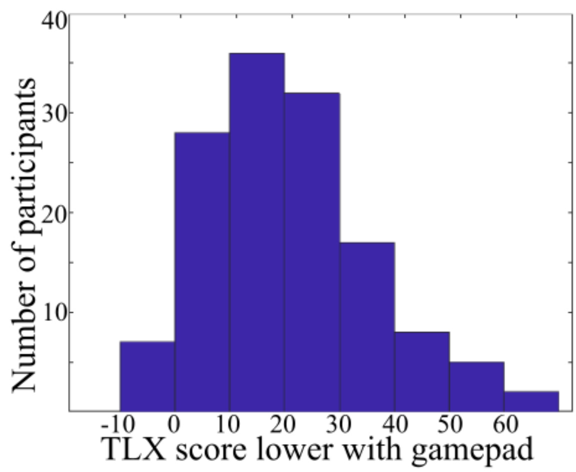

Figure 10: Histogram of mean joystick workload minus mean gamepad workload

the joystick. The score difference is in favour of the gamepad for the majority of participants and, in some cases, this is by up to 60 points. To illustrate the differences and how participants scored each subscale generally, the mean workload scores were calculated and are as follows:

Table 2: Workload averages (as a score out of 100)

Workload factor	Joystick	Gamepad
Mental demand	50.78	28.93
Physical demand	29.00	18.74
Temporal demand	53.04	37.15
Performance	45.41	31.26
Effort	59.22	32.81
Frustration	49.48	23.33
Average	47.82	28.70

As the table shows, the average scores for mental demand, effort and frustration were far lower for the gamepad. These factors are considered to be very important for the case of the soldier that is unfamiliar with a new control system, as the specific case in Section 1 highlighted. They are also important in considering the design of a control system, as minimising temporal demand and effort may also reduce the time it takes to effectively train someone in that control system. Figures 9 and 10 show that the vast majority of participants recorded lower workload scores with the gamepad compared to the joystick (94.81 %). As the relative time difference between controllers also alluded to, participants found it easier to use the gamepad, and they recorded higher workload scores for the joystick (mean difference: 38.46 % higher than the gamepad).

3.3 Experience levels in participants

The definitions of each level of experience were provided to participants in the pre-simulation questionnaire (Appendix A) and are as follows:

- never: had never used before,
- rare: used once a month or less,
- infrequent: used several times per month, and
- frequent: used at least once per week.

Participants were more familiar with the gamepad compared to the joystick: 42.22 % of participants had some prior exposure to any kind of joystick, compared to 92.59 % having some prior exposure to a gamepad at some level. The disparity in experience levels can be seen in Figure 11 (above right). In itself, it is a telling statistic of what the participants were familiar with when 57.78 % had never used any kind of joystick before. A total of 70.37 % of participants identified primarily with Xbox or Playstation, systems that use a gamepad as the control interface. 22.96 % of participants identified with PC and 6.67 % identified with other systems (Wii, mobile gaming, etc.).

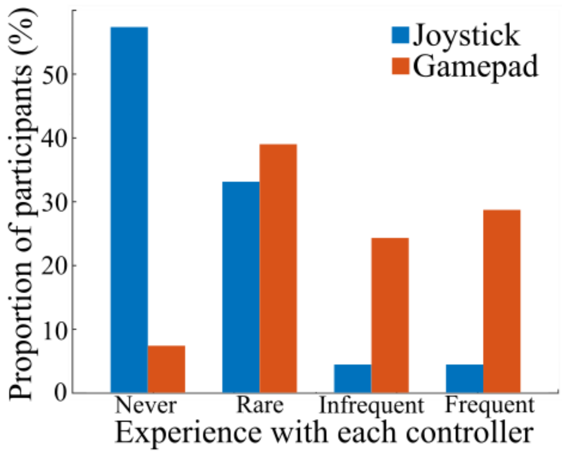

Figure 11: Histogram of participant experience with each controller

Participants also largely identified with game genres that benefit from similar control layouts to that of the gamepad in the simulation. The distribution of participants' preference of game genre is in Table 3:

Table 3: Participant preference of game genre

Game genre	Participants (%)
First person shooter	52.59
Adventure	16.30
Other	14.81
Racing	10.37
Real time strategy	5.93

As can be seen from the table, more than half of the participants identified with a single game genre: first person shooter. For gamepad devices, the control layout of a first person shooter game mirrors the control layout used in the simulation. The exception is that the left thumbstick typically controls movement of game characters and the right thumbstick controls visual direction. In the simulation, there was no movement of the vehicle, so this was not something that could be confused. As mentioned in Section 2.3.3, participants also had access to visual aids to confirm how the controller worked. Nevertheless, participants identified highly with the first person shooter game genre and game devices that use gamepads.

3.4 Experience levels and higher performance with the gamepad

Despite the popularity of gamepads as control devices, there were still participants that also identified as infrequent or frequent users of joysticks (six and six participants respectively). These numbers of participants were significantly lower than those that identified as infrequent or frequent gamepad users (33 and 39 participants respectively). The differing levels of experience were only found to be statistically significant for the gamepad. Table 4 shows the mean total times for each controller based on experience level with that controller:

Table 4: Mean total times by experience level

Experience	Joystick (s)	Gamepad (s)
Never	68.19	57.12
Rare	62.88	49.07
Infrequent	61.08	48.17
Frequent	59.01	43.66

Prima facie, both the joystick and the gamepad show mean total times decreasing as experience increases. However, one-way analyses of variance (ANOVA) at the 5 % significance level were conducted to assess how reliable the data was in determining a meaningful relationship between experience and time taken. On the ANOVA plots in Figures 12 and 13, the black horizontal lines indicate extrema, the blue horizontal lines show 25th and 75th percentiles, the red horizontal line shows the sample data mean, and the blue notches indicate the 95 % confidence interval for the mean of the broader population (not just the participants sampled). The primary output from a one-way ANOVA is a p-value between zero and one. The p-value represents the likelihood that assessed criteria are significant. At the 95 % significance level, a p-value greater than 0.05 indicates a lack of evidence that the assessed criteria was significant (the criteria had little or no impact). A p-value less than 0.05 indicates stronger evidence of difference between assessed factors (one or more factors influenced the results).

The one-way ANOVA in Figure 12 yielded a p-value of 0.0029, suggesting that there is strong evidence that the overall ADF population would have different total time taken means for different experience levels with the gamepad. More succinctly, more experience could correlate with better performance in the wider ADF population. This supports the conclusions by Rupp et al. (2013), who also found that

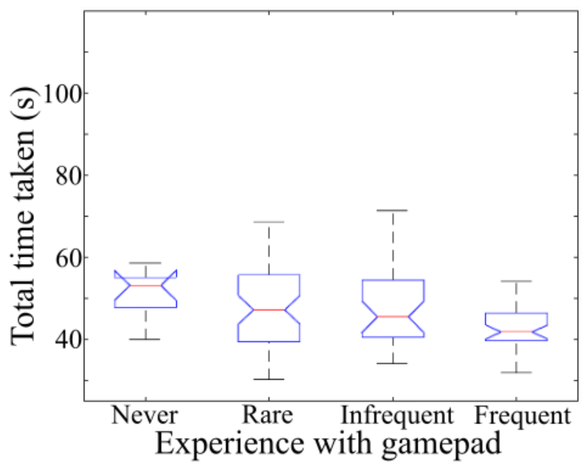

Figure 12: ANOVA of gamepad performance

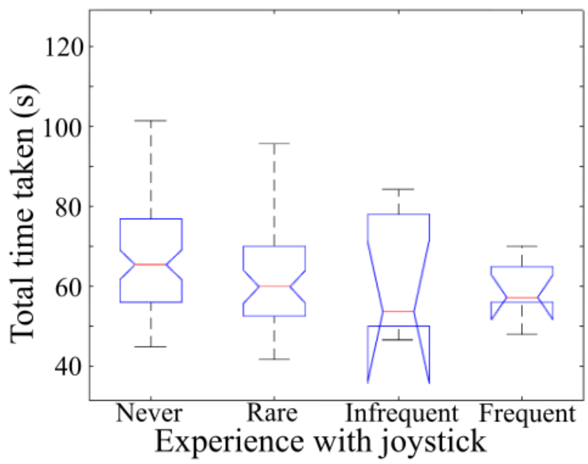

Figure 13: ANOVA of joystick performance

participants who are experienced with gamepads will perform better with gamepads. The same one-way ANOVA was conducted on the joystick experience levels as per Figure 13. Here, the ANOVA yielded a p-value of 0.1785, significantly higher. Such a high p-value rejects the assertion that experience influences time taken with the joystick. A supporting explanation for this could be that gaming joysticks are not configured like the M113AS4 turret controller so very few participants would have had prior experience with the configuration. It could also be due to the fact that only 12 participants identified as infrequent or frequent users of joysticks, restricting the relevance of the data (as shown by the larger confidence intervals on Figure 13 compared to Figure 12). Alternatively, given the workload scores established in Section 3.2, it could be the case that the fixed-handle joystick is difficult to be proficient with, regardless of experience level.

3.5 Performance differences between units

There was no significant difference in simulation performance between the units that participated in the research. Despite the variations in some statistics (highlighted in Table 5), the mean simulation completion times were not significantly different. Similar to the experience with joystick and gamepad ANOVAs in Section 3.4, ANOVAs were conducted on the three units and total times taken with each controller. The p-values for

Table 5: Highlighted differences between units

Mean factors	ADFA	AFG	RMC-D
Age (y)	20.24	28.85	23.73
Service length (y)	2.17	6.71	2.94
Joystick mean total time (s)	68.48	70.55	58.09
Gamepad mean total time (s)	48.03	46.26	47.92

the joystick and the gamepad were 0.7629 and 0.9206 respectively. These are extremely high and indicate that there is no evidence that the unit a participant came from had any bearing on their performance with either controller. Given the average age of the Australian gamer is 34 years old (Brand, Todhunter, & Jervis, 2017), the relative age and service length differences between units was not expected to be a contributing factor to performance in the simulation and this expectation is also justified through the minimally different mean times.

4 A control system solution

As a result of this research, a turret control system solution proposed for the M113AS4 is a two-handed controller that:

- decouples movement from firing,
- is based on the ergonomic design of the Xbox One controller,
- exploits the majority of personnel being familiar with gamepads, and
- reduces training and maintenance burden on units and the Army in general.

4.1 A supported system

In this research, a two-handed controller that implements one hand to control turret movement and the other hand to control firing of the weapon system was found to be better at a simple target engagement simulation than a fixed-handle joystick. The decoupled movement from firing is an inherent outcome of conducting the research with the gamepad. Given the two-handed requirement, the solution would also need to sit centrally in the turret in front of the crew commander. The joystick palm switch and a gamepad-style equivalent were not considered within the scope of this research. Further analysis is needed in this respect.

4.2 Ergonomic design

In order to ensure ergonomic integration of a two-handed controller, the proposed solution would emulate the style and layout of the Xbox One controller. This controller has undergone extensive research and testing by Microsoft (exceeding $100 M) to make it as ergonomic as possible for the Xbox user (Pitcher, 2013). The proposed solution would maintain the left thumbstick and right trigger as they were used in the research simulation but would remove all other buttons. If the button to unlock use of the controller (current turret controller palm switch) is a necessary consideration, then it would be proposed that this be integrated as the gamepad controller left trigger. Additionally, as the current turret controller has a secondary use of being a handle for the crew commander to hold on to, the proposed solution would be a fixed controller that crew commanders could also use to stabilise themselves over rough terrain. The position to mount a gamepad-based controller in the M113AS4 turret is indicated in Figure 14, between the crew commander sight and the ammunition feed tray.

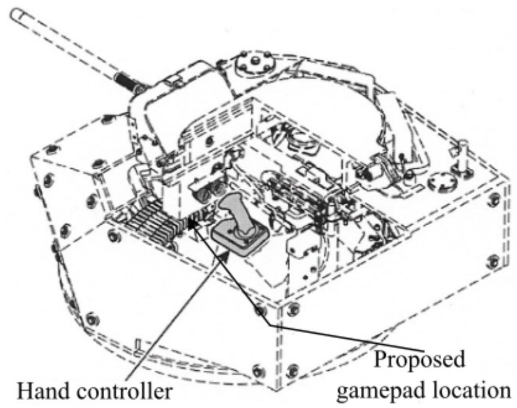

Figure 14: Position to mount a proposed gamepad-based controller (MM, 2014)

4.3 Reducing training burden

As was established in Section 3.3, 92.59 % of research participants had some level of prior experience with a gamepad and 70.37 % identified that their primary system for gaming was an Xbox or a Playstation. It was shown in Section 3.4 that higher experience levels with the gamepad also correlated with higher proficiency (as indicated by shorter times taken in the simulation). This could reduce training burden as the majority of new trainees with the system would have some base level of proficiency already (Tannahill, 2013).

4.4 Training and maintenance solutions

In Australia, a gamepad like the Xbox One controller can be purchased privately for approximately $65.00 (PC Case Gear, 2017). With low cost and the ability to integrate gamepads into software simulations like the one created for this research, additional training outside of the M113AS4 turret could become more feasible. Individual Army units could have banks of computers set up with simulation software to maintain the skills of their crew commanders (and familiarise unqualified personnel) with the controls. Maintenance costs for simulation software and the simulation controllers would be low (no more than personal costs for home console owners). Although this does not consider the case of potential legal issues arising from the use of Microsoft equipment in military training, there is still potential for training solutions. The use of simulation and computer-based training could reduce financial burdens for Army as it could mean less time training with live ammunition at live firing ranges, meaning lower costs of ammunition, fuel and support staff such as live firing range operators.

5 Conclusion

The original aim of this report was to establish whether or not the Australian Army should consider the integration of gaming controllers into military engineering design. The data from the research experiment suggests that in simulation conditions, untrained military personnel perform better with a gamepad than with a joystick. The research experiment sought to analyse participant performance in a target engagement exercise and provide explanations for performance differences between participants through collection of background data. It was shown that not only were the majority of participants more proficient with the gamepad than the joystick (mean total times: 47.67 s against 65.70 s), but the majority of participants had more experience with the gamepad than the joystick (prior exposure: 92.59 % against 42.22 %) and had lower workload scores for the gamepad than the joystick (mean workload scores: 28.70 against 47.82). Additionally, most participants preferred gamepad-based systems (70.37 %) and just over half preferred the first person shooter gaming genre (52.59 %). Lastly, those that had more experience with the gamepad also performed better in the simulation with it ($p = 0.0029$). These facts show that research participants were more comfortable, more experienced and faster with a gamepad than a fixed-handle joystick in simulated target engagement exercises.

Integrating such an engineering solution into the M113AS4 turret shows the potential to reduce training burdens for the Australian Army as it could take advantage of the majority of new trainees already having some prior experience with a similar system. It could also satisfy the original scenario considered by this research: an untrained and unfamiliar soldier required to operate the turret in exceptional circumstances. Further study to confirm the merit in this research's conclusions could include the design and prototyping of a gamepad-based turret controller that could be compared against the standard controller with both experienced and inexperienced users. Long-term training and skills development should also be considered for the system to be justified. Lastly, cost analysis and feasibility of integration with vehicle and simulation systems could be conducted.

Ethical clearance for this project was provided by the Departments of Defence and Veterans Affairs Human Research Ethics Committee.

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A Pre-simulation questionnaire

SEIT, UNSW Canberra

Participant Questionnaire

Are ADF members pre-disposed to learning with an Xbox controller compared to the current joystick-based M113AS4 turret controller?

Name : ______________________________

Age: ____________ Gender: M F

Service: ____________ Time in service: ____________

1 **Which gaming system do you most identify with?**

PC Xbox Playstation Other

2 **How many hours a week would you play video games during a standard week?**

0 1 to 3 4 to 6 More than 6

3 **Typically, how much would you game with a hand-held controller (Xbox style)?**

Never used Rare (once a month or less)

Infrequent (several times a month) Frequent (at least once a week)

4 **Typically, how much would you game with a joystick?**

Never used Rare (once a month or less)

Infrequent (several times a month) Frequent (at least once a week)

5 **Which class of game do you most identify with?**

Racing Adventure FPS RTS Other

6 **How old were you when you first started gaming?** ____________

7 **Have you ever played games online?**

Yes No

8 **Are you left or right hand dominant?**

Left Right

9 **Have you ever played a hand-dominant sport competitively before (AFL, hockey etc)?**

Yes No

B NASA TLX

SEIT, UNSW Canberra

NASA Task Load Index Please circle an area on the scales to indicate your experience

Name : ____________

Joystick Controller

Mental demand How mentally demanding was the task?

Very low Very high

Physical demand How physically demanding was the task?

Very low Very high

Temporal demand How hurried or rushed was the pace of the task?

Very low Very high

Performance How successful were you in accomplishing the task?

Perfect Failure

Effort How hard did you have to work to achieve your level of performance?

Very low Very high

Frustration How insecure, discouraged, stressed or annoyed were you?

Very low Very high

Xbox One Controller

Mental demand How mentally demanding was the task?

Very low Very high

Physical demand How physically demanding was the task?

Very low Very high

Temporal demand How hurried or rushed was the pace of the task?

Very low Very high

Performance How successful were you in accomplishing the task?

Perfect Failure

Effort How hard did you have to work to achieve your level of performance?

Very low Very high

Frustration How insecure, discouraged, stressed or annoyed were you?

Very low Very high

C Raw data

	Consent provided	Age	Gender	Service	Time in service	System most identified with	Hours a week played	Experience with Xbox controller	Experience with joystick	Class of game identified with	Age first started gaming	Played online	Hand dominance	Played hand dominant sports	Unit	Joystick blue time	Joystick yellow time	Joystick red time	Joystick total time	Joystick average time	Xbox blue time	Xbox yellow time	Xbox red time	Xbox total time	Xbox average time	Relative difference	Joystick mental demand	Joystick physical demand	Joystick temporal demand	Joystick performance	Joystick effort	Joystick frustration	Joystick overall rating	Xbox mental demand	Xbox physical demand	Xbox temporal demand	Xbox performance	Xbox effort	Xbox frustration	Xbox overall rating
Option 1 sum	135		117	75		31	43	10	78	14		113	18	110	69																									
Option 2 sum	0		18	30		41	60	53	45	22		22	117	25	29																									
Option 3 sum				30		54	16	33	6	71					37																									
Option 4 sum						9	16	39	6	8																														
Option 5 sum										20																														
Mean		22.9			3.31						9.86					19.17	20.75	25.78	65.7	21.9	14.51	15.69	17.47	47.67	15.89	0.261	50.8	29	53	45.4	59.2	49.5	47.8	28.9	18.7	37.1	31.3	32.8	23.3	28.7
Standard deviation		4.71			3.21						4.04					4.708	5.435	9.289	15.89	5.297	3.485	3.654	5.785	11.23	3.745	0.133	22.2	22.9	19.9	19.1	20	26.8	15.6	18.9	15.8	21.2	21.5	21.2	19	13.8
	Y	20	M	AF	1.5	XB	0	RA	NV	FPS	8	Y	R	Y	ADFA	21.6	19.77	23.43	64.8	21.6	11.08	15.13	11.92	38.13	12.71	0.412	60	55	60	45	65	50	55.8	35	25	40	80	25	25	38.3
	Y	20	M	A	1.5	PS	3	FR	NV	FPS	12	Y	R	Y	ADFA	27.92	23.37	23.54	74.83	24.94	17.12	13.25	16.33	46.7	15.57	0.376	45	0	50	55	25	50	37.5	15	0	20	50	20	5	18.3
	Y	20	M	AF	2	PC	0	RA	RA	ADV	12	Y	R	Y	ADFA	20.22	20.17	23.48	63.87	21.29	12.49	13.46	14.7	40.65	13.55	0.364	30	40	60	85	65	55	55.8	5	5	25	90	5	10	23.3
	Y	20	M	N	3	PS	3	RA	NV	FPS	16	Y	R	Y	ADFA	24.9	20.81	31.85	77.56	25.85	12.17	15.14	16.1	43.41	14.47	0.44	85	5	70	65	80	25	55	25	5	20	15	25	10	16.7
	Y	21	M	A	3	PS	0	RA	NV	OTH	6	Y	R	Y	ADFA	15.78	16.9	18.84	51.52	17.17	10.59	18.25	12.33	41.17	13.72	0.201	20	5	50	20	30	55	30	10	5	55	30	45	65	35
	Y	21	M	N	3	PS	3	FR	FR	OTH	17	Y	R	Y	ADFA	18.98	20.5	16.71	56.19	18.73	10.95	11.43	18.23	40.61	13.54	0.277	75	15	70	40	70	80	58.3	60	15	70	35	60	75	52.5
	Y	21	M	AF	3	PS	3	IN	RA	FPS	13	Y	R	Y	ADFA	28.84	23.78	28.12	80.74	26.91	16.26	20.84	25.2	62.3	20.77	0.228	35	15	40	65	45	55	42.5	30	10	15	35	20	25	22.5
	Y	24	M	N	3.5	PS	3	IN	NV	RAC	10	Y	R	Y	ADFA	27.68	24.58	24.72	76.98	25.66	21.51	16.7	20.75	58.96	19.65	0.234	40	5	10	15	10	15	15.8	25	5	5	5	5	10	9.17
	Y	20	M	A	1.5	PS	0	RA	NV	RTS	16	Y	R	Y	ADFA	20.28	23.27	58	101.6	33.85	16.66	16.43	35.72	68.81	22.94	0.322	75	65	70	85	65	80	73.3	50	50	50	45	50	50	49.2
	Y	20	M	A	1.5	PS	6	FR	NV	FPS	10	Y	R	Y	ADFA	17.15	19.47	24.67	61.29	20.43	10.35	14.4	14.66	39.41	13.14	0.357	50	50	50	60	75	70	59.2	50	30	50	20	30	35	35.8
	Y	18	M	AF	0.7	XB	0	RA	FR	RTS	12	N	R	Y	ADFA	18.03	20.22	26.8	65.05	21.68	16.22	14.74	16.63	47.59	15.86	0.268	50	25	55	65	75	80	58.3	5	5	5	15	5	5	6.67
	Y	18	F	A	0.7	XB	0	IN	NV	FPS	14	N	R	Y	ADFA	15.04	27.15	38.42	80.61	26.87	11.43	15.18	15.02	41.63	13.88	0.484	60	75	75	75	75	85	74.2	35	10	10	10	10	5	13.3
	Y	18	M	AF	0.7	XB	0	RA	RA	FPS	11	Y	R	N	ADFA	22.93	21.68	30.41	75.02	25.01	18.72	15.97	15.43	50.12	16.71	0.332	70	35	70	80	80	85	70	25	25	50	25	30	20	29.2
	Y	21	M	N	2	XB	3	FR	NV	RAC	12	Y	L	Y	ADFA	19.41	19.31	18.83	57.55	19.18	13.01	14.85	17.77	45.63	15.21	0.207	80	10	75	35	65	50	52.5	10	5	40	20	60	50	30.8
	Y	20	M	AF	1	XB	3	FR	NV	FPS	8	Y	L	N	ADFA	22.16	23.1	32.16	77.42	25.81	14.38	15.2	21.24	50.82	16.94	0.344	75	15	75	45	70	50	55	55	45	75	25	50	35	47.5
	Y	20	M	A	2	OTH	3	IN	RA	ADV	6	Y	R	N	ADFA	17.31	18.46	21.16	56.93	18.98	14.1	12.91	13.66	40.67	13.56	0.286	70	25	60	65	70	75	60.8	40	25	65	20	35	20	34.2
	Y	25	M	AF	2.5	PS	3	RA	RA	FPS	10	Y	R	Y	ADFA	28.33	17.21	27.94	73.48	24.49	15.56	18.01	18.38	51.95	17.32	0.293	70	15	40	40	70	75	51.7	65	45	25	25	40	50	41.7
	Y	23	M	AF	2.5	XB	0	RA	IN	FPS	10	Y	R	Y	ADFA	17.96	16.4	21.51	55.87	18.62	11.68	13.14	12.05	36.87	12.29	0.34	85	20	80	25	70	65	57.5	50	10	55	30	55	45	40.8
	Y	21	M	N	3	PC	6	RA	IN	FPS	11	Y	R	N	ADFA	18.93	20.74	44.61	84.28	28.09	13.68	12.59	13.32	39.59	13.2	0.53	65	30	55	70	55	65	56.7	35	25	45	15	30	25	29.2
	Y	20	M	A	2	PS	0	IN	NV	FPS	8	Y	R	Y	ADFA	25.73	19.04	20.97	65.74	21.91	11.92	14.14	14.25	40.31	13.44	0.387	35	45	65	25	45	15	38.3	20	25	30	15	15	15	20
	Y	20	M	AF	1.5	PS	0	RA	RA	FPS	8	Y	R	Y	ADFA	13.9	25.77	20.28	59.95	19.98	12.46	15.69	17.25	45.4	15.13	0.243	30	0	60	40	80	50	43.3	10	0	50	20	50	25	25.8
	Y	19	M	A	0.7	PC	3	IN	RA	RTS	6	Y	R	Y	ADFA	14.5	23.49	22.92	60.91	20.3	16.1	22.46	16.59	55.15	18.38	0.095	40	40	60	40	60	65	50.8	20	20	60	45	35	65	40.8
	Y	19	F	A	1.5	PS	3	FR	NV	ADV	5	N	L	Y	ADFA	16.1	15.53	19.74	51.37	17.12	11.45	13.17	16.43	41.05	13.68	0.201	65	65	80	25	80	65	63.3	55	55	80	10	55	25	46.7
	Y	20	M	A	3	XB	9	FR	RA	FPS	3	Y	R	N	ADFA	19.81	25.47	22.3	67.58	22.53	12.55	12.85	16.27	41.67	13.89	0.383	50	50	75	55	65	50	57.5	5	5	5	20	15	0	8.33
	Y	19	M	AF	0.75	PS	3	FR	RA	FPS	6	Y	R	Y	ADFA	19.72	16.64	21.09	57.45	19.15	10.62	12.48	11.49	34.59	11.53	0.398	65	55	60	55	75	80	65	35	30	50	25	25	15	30
	Y	19	M	AF	0.75	PC	3	IN	NV	FPS	6	Y	L	Y	ADFA	16.18	14.83	23.77	54.78	18.26	11.64	14.05	13.55	39.24	13.08	0.284	70	15	85	70	75	85	66.7	35	20	15	15	20	15	20
	Y	19	M	A	0.7	PC	3	IN	RA	OTH	14	Y	R	Y	ADFA	22.4	18.26	23.66	64.32	21.44	13.07	12.54	13.31	38.92	12.97	0.395	10	55	45	15	85	20	38.3	5	5	45	5	5	5	11.7
	Y	21	F	N	2	OTH	0	NV	NV	RAC	10	N	L	Y	ADFA	25.61	40.37	51.61	117.6	39.2	21.78	34.8	59.26	115.8	38.61	0.015	75	50	60	25	65	75	58.3	50	45	50	50	55	55	50.8
	Y	20	F	A	2	PS	3	IN	NV	FPS	10	Y	R	N	ADFA	21.29	18.99	26.49	66.77	22.26	12.61	16.18	16.25	45.04	15.01	0.325	50	5	35	30	20	20	26.7	50	5	40	15	10	10	21.7
	Y	22	M	N	3	PC	0	NV	NV	RAC	6	N	R	Y	ADFA	21.3	21.52	27.05	69.87	23.29	13.08	15.53	20.15	48.76	16.25	0.302	20	10	15	20	35	15	19.2	10	10	15	30	25	5	15.8
	Y	19	M	A	1.5	XB	0	RA	RA	RAC	8	Y	R	Y	ADFA	23.46	30.01	27.14	80.61	26.87	15.11	16.14	21.24	52.49	17.5	0.349	70	55	60	50	60	45	56.7	60	30	30	40	35	25	36.7
	Y	21	M	A	3	PC	9	IN	NV	FPS	6	Y	R	Y	ADFA	15.9	20.26	25.73	61.89	20.63	15.11	16.24	16.39	47.74	15.91	0.229	50	15	75	50	75	85	58.3	15	15	80	25	25	35	32.5
	Y	20	M	A	3	XB	3	RA	NV	FPS	14	Y	R	Y	ADFA	20.69	21.29	23.26	65.24	21.75	12.7	15.12	22.58	50.4	16.8	0.227	55	25	70	10	30	5	32.5	5	5	20	5	15	5	9.17
	Y	22	M	A	2	PS	3	RA	RA	RAC	14	Y	R	Y	ADFA	16.12	16.3	17.29	49.71	16.57	12.94	13.7	19.69	46.33	15.44	0.068	50	60	50	25	65	35	47.5	35	35	60	25	20	25	33.3
	Y	20	F	AF	1.7	PC	0	RA	RA	OTH	12	Y	R	N	ADFA	35.46	30.5	42.26	108.2	36.07	20.55	18.08	24.51	63.14	21.05	0.417	45	35	50	30	25	15	33.3	20	15	20	15	15	10	15.8
	Y	22	M	N	2.5	PC	6	NV	NV	FPS	3	Y	R	Y	ADFA	19.42	16.65	20.07	56.14	18.71	14.09	12.26	13.71	40.06	13.35	0.286	50	15	35	20	35	5	26.7	35	0	10	0	0	0	7.5
	Y	20	M	A	3	PS	0	RA	NV	FPS	8	N	R	Y	ADFA	23.1	21.7	25.03	69.83	23.28	14.96	22.28	11.03	48.27	16.09	0.309	65	50	45	85	55	45	57.5	40	30	40	20	30	20	30
	Y	20	F	N	3	OTH	0	RA	NV	ADV	15	N	R	Y	ADFA	24.04	30.24	39.41	93.69	31.23	13.97	18.04	18.18	50.19	16.73	0.464	80	45	70	45	80	80	66.7	45	20	40	25	45	45	36.7
	Y	21	F	A	3	OTH	0	RA	NV	OTH		N	R	Y	ADFA	21.13	19.72	75.6	116.5	38.82	18.35	19.41	23.14	60.9	20.3	0.477	70	50	25	55	85	65	58.3	55	45	85	65	55	40	57.5
	Y	19	M	A	2	PC	3	RA	NV	FPS	15	Y	R	Y	ADFA	15.6	22.17	21.52	59.29	19.76	16.48	16.13	14.67	47.28	15.76	0.203	40	25	55	20	70	15	37.5	20	35	30	20	35	20	26.7
	Y	18	M	A	0.7	XB	3	FR	NV	FPS	12	Y	R	N	ADFA	19.16	17.22	31.15	67.53	22.51	13.29	22.35	18.69	54.33	18.11	0.195	80	75	50	35	75	20	55.8	20	15	25	25	65	10	26.7
	Y	20	M	N	2	PS	3	FR	NV	FPS	6	Y	R	N	ADFA	19.72	15.86	19.45	55.03	18.34	12.68	14.76	17.37	44.81	14.94	0.186	55	0	55	50	65	55	46.7	35	0	45	30	25	30	27.5
	Y	19	M	N	1.5	PS	0	RA	NV	FPS	13	Y	R	Y	ADFA	18.74	19.46	27.94	66.14	22.05	14.99	14.26	22.18	51.43	17.14	0.222	60	50	45	65	65	55	56.7	50	45	45	35	45	40	43.3
	Y	20	M	N	2	XB	0	IN	NV	FPS	9	Y	R	Y	ADFA	22.32	18.14	24.79	65.25	21.75	15.56	16.3	18.41	50.27	16.76	0.23	60	60	75	70	90	80	72.5	35	35	50	35	30	30	35.8
	Y	18	M	AF	0.7	PC	6	FR	RA	OTH	13	Y	L	Y	ADFA	19.8	14.83	16.32	50.95	16.98	12.04	13.74	16.6	42.38	14.13	0.168	15	15	75	30	75	55	44.2	10	10	75	20	70	40	37.5
	Y	18	F	A	1.5	PC	0	RA	NV	OTH	15	Y	R	Y	ADFA	17.15	28.59	22.66	68.4	22.8	12.21	13.35	17.6	43.16	14.39	0.369	70	40	20	25	65	95	52.5	35	30	70	70	15	20	40
	Y	20	M	N	3	PC	3	NV	NV	OTH	14	Y	R	N	ADFA	16.06	21.35	21.89	59.3	19.77	14.85	16.48	20.21	51.54	17.18	0.131	65	50	65	25	70	40	52.5	50	35	45	20	60	20	38.3
	Y	19	F	A	1.5	PC	3	RA	NV	OTH	7	Y	R	Y	ADFA	18.26	26.94	21.95	67.15	22.38	24.82	20.94	22.35	68.11	22.7	-0.01	75	20	75	20	70	85	57.5	90	20	90	15	75	80	61.7
	Y	21	M	A	2.3	XB	0	IN	RA	FPS	10	Y	R	Y	ADFA	19.38	23.27	42.84	85.49	28.5	16.16	17.97	20.28	54.41	18.14	0.364	40	5	10	10	45	70	30	10	0	35	55	35	40	29.2
	Y	20	M	AF	0.75	XB	3	RA	RA	FPS	14	Y	R	N	ADFA	23.72	24.11	28.19	76.02	25.34	16.55	19.51	21.66	57.72	19.24	0.241	25	5	40	30	65	15	30	10	5	55	20	60	15	27.5
	Y	21	M	AF	2	PC	6	RA	RA	RTS	6	Y	R	Y	ADFA	16.68	20.29	25.36	62.33	20.78	13.48	13.96	18.13	45.57	15.19	0.269	80	25	65	70	60	65	60.8	45	35	60	75	45	50	51.7
	Y	30	M	AF	13	PC	6	IN	IN	OTH	10	N	R	Y	ADFA	14.07	18.12	14.48	46.67	15.56	15.6	14.14	16.56	46.3	15.43	0.008	65	60	35	40	70	65	55.8	55	45	35	25	70	55	47.5
	Y	33	M	AF	16	XB	9	FR	RA	FPS	6	Y	R	N	ADFA	13.97	12.98	18.96	45.91	15.3	9.67	10.25	12.01	31.93	10.64	0.305	65	25	70	55	65	25	50.8	40	10	55	20	40	10	29.2
	Y	20	M	AF	0.7	XB	3	FR	RA	FPS	8	Y	R	Y	ADFA	18.27	20.52	22.33	61.12	20.37	11.14	15.9	13.4	40.44	13.48	0.338	80	20	75	40	85	85	64.2	45	25	50	25	60	35	40
	Y	19	M	A	0.7	XB	3	FR	NV	FPS	10	Y	R	Y	ADFA	14.45	19.57	19.42	53.44	17.81	10.83	14.94	14.41	40.18	13.39	0.248	60	20	65	65	75	65	58.3	5	5	25	65	25	15	23.3
	Y	18	M	A	0.7	PC	6	IN	NV	ADV	7	Y	L	N	ADFA	12.83	19.92	48.56	81.31	27.1	12.17	19.56	13.71	45.44	15.15	0.441	20	15	40	60	40	70	40.8	15	15	35	40	25	25	25.8
	Y	20	M	N	1.5	PC	3	IN	FR	RAC	10	Y	L	Y	ADFA	18.2	23.3	28.69	70.19	23.4	12.85	15.05	14.77	42.67	14.22	0.392	65	70	75	50	65	55	63.3	40	45	50	35	45	35	41.7
	Y	18	M	A	0.7	XB	3	FR	NV	FPS	11	Y	L	Y	ADFA	15.59	16.59	21.26	53.44	17.81	12.81	16.56	12.76	42.13	14.04	0.212	45	15	65	25	70	20	40	15	15	85	15	65	10	34.2

[redacted]

Y	18	M	A	1.7	XB	0	RA	RA	RAC	9	Y	R	Y	ADFA	15.36	18.47	19	52.83	17.61	10.19	12.7	12.93	35.82	11.94	0.322	20	0	70	10	40	55	32.5	5	5	15	90	65	55	39.2
Y	19	F	AF	0.75	PS	3	IN	NV	OTH	6	Y	R	Y	ADFA	21.51	39.19	27.85	88.55	29.52	21.34	22.02	28.04	71.4	23.8	0.194	85	80	75	35	70	55	66.7	55	65	55	30	70	30	50.8
Y	19	M	N	1.7	PS	3	FR	RA	FPS	4	Y	R	Y	ADFA	31.92	30.71	33	95.63	31.88	21.13	20.14	19.68	60.95	20.32	0.363	60	55	65	60	70	65	62.5	40	20	45	75	55	15	41.7
Y	19	M	N	1.7	PS	3	IN	NV	FPS	5	Y	R	Y	ADFA	16.01	19.44	20.69	56.14	18.71	14.5	17.92	14.73	47.15	15.72	0.16	30	25	55	60	60	35	44.2	15	15	40	75	30	15	31.7
Y	27	M	A	8	XB	9	FR	RA	ADV	10	Y	R	Y	AFG	16.56	20.04	30.63	67.23	22.41	14.71	12.52	11.63	38.86	12.95	0.422	20	10	25	25	25	30	22.5	15	5	20	10	10	10	11.7
Y	32	M	A	8	XB	3	FR	RA	FPS	10	Y	R	N	AFG	22.19	14.47	19.56	56.22	18.74	11.12	12.49	17.57	41.18	13.73	0.268	70	35	70	40	65	70	58.3	45	15	45	20	45	30	33.3
Y	29	M	A	5	PS	3	IN	NV	FPS	10	Y	R	Y	AFG	26.69	14.72	25.41	66.82	22.27	11.31	13.73	17.53	42.57	14.19	0.363	65	35	55	65	70	20	51.7	60	35	55	75	55	20	50
Y	30	M	AF	11	XB	6	RA	NV	FPS	9	Y	R	Y	AFG	18.37	19.53	19.75	57.65	19.22	9.59	9.79	11.01	30.39	10.13	0.473	30	40	40	15	15	50	31.7	0	0	5	0	0	5	1.67
Y	37	M	AF	14	PS	0	NV	NV	RAC		N	R	Y	AFG	15.09	22.89	22.78	60.76	20.25	13.44	16.11	25.66	55.21	18.4	0.091	10	20	20	50	20	45	27.5	10	10	45	50	10	55	30
Y	36	M	AF	5	OTH	0	RA	RA	OTH		N	R	Y	AFG	28.94	29.91	28.24	87.09	29.03	15.46	16.08	25.86	57.4	19.13	0.341	0	0	40	50	50	0	23.3	5	5	5	35	20	0	11.7
Y	27	M	N	5	PS	0	RA	RA	FPS	8	Y	R	N	AFG	22.04	14.94	23.13	60.11	20.04	12.37	13.63	12.4	38.4	12.8	0.361	70	65	60	60	65	95	69.2	35	25	30	25	10	5	21.7
Y	21	M	A	3	PS	9	FR	RA	FPS	10	Y	R	Y	AFG	12.7	16.37	19.99	49.06	16.35	8.65	9.62	11.01	29.28	9.76	0.403	75	25	50	50	50	75	54.2	50	20	50	25	35	15	32.5
Y	25	M	AF	7	PC	0	IN	IN	RAC	6	Y	R	Y	AFG	9.75	15.29	25.09	50.13	16.71	11.17	10.76	12.34	34.27	11.42	0.316	20	0	50	50	50	50	36.7	5	0	50	50	50	15	28.3
Y	28	F	A	7.5	PS	0	RA	NV	ADV	8	N	R	Y	AFG	18.61	33.87	32.2	84.68	28.23	21.27	14.84	17.73	53.84	17.95	0.364	55	5	55	25	60	65	44.2	55	0	20	55	20	25	29.2
Y	26	M	A	7	XB	0	RA	NV	FPS	10	Y	R	N	AFG	18.89	19.72	18.61	57.22	19.07	8.56	12.41	15.86	36.83	12.28	0.356	65	40	65	45	10	0	37.5	25	40	45	25	10	0	24.2
Y	40	M	A	12	PS	3	FR	FR	FPS	4	Y	R	Y	AFG	15.72	17.69	24.08	57.49	19.16	11.34	9.88	14.13	35.35	11.78	0.385	50	50	35	80	70	70	59.2	10	10	10	15	10	10	10.8
Y	28	M	N	9.7	PS	3	NV	NV	ADV	12	N	R	Y	AFG	20.86	22.36	21.98	65.2	21.73	14.34	17.5	15.96	47.8	15.93	0.267	75	10	55	35	75	55	50.8	25	15	15	90	10	10	27.5
Y	27	M	A	8	PS	3	RA	RA	FPS		Y	R	Y	AFG	17.6	19.06	21.43	58.09	19.36	15.93	15.73	16.74	48.4	16.13	0.167	60	65	65	60	65	65	63.3	45	40	35	35	40	50	40.8
Y	21	F	N	3	PC	0	RA	NV	OTH		N	R	N	AFG	27.99	30.67	33.64	92.3	30.77	18.02	23.29	26.77	68.08	22.69	0.262	50	10	50	50	65	65	48.3	30	10	50	25	40	20	29.2
Y	23	M	N	4	XB	6	FR	NV	FPS	6	Y	R	N	AFG	24.14	19.55	28.98	72.67	24.22	13.27	12.06	16.56	41.89	13.96	0.424	50	5	90	75	80	100	66.7	25	5	40	15	10	10	17.5
Y	25	F	N	4	PS	3	RA	NV	OTH	11	Y	R	Y	AFG	25.03	28.78	34.72	88.53	29.51	13.87	18.52	18.22	50.61	16.87	0.428	55	5	35	50	70	55	45	5	5	5	15	5	5	6.67
Y	32	M	N	2.75	OTH	3	IN	NV	OTH	5	N	R	Y	AFG	20.28	20.23	38.99	79.5	26.5	14.45	18	19.52	51.97	17.32	0.346	35	40	35	40	60	55	44.2	20	15	15	15	15	10	15
Y	21	M	N	3	PS	0	NV	RA	FPS	9	N	R	Y	AFG	20.33	18.46	29.82	68.61	22.87	14.46	17.15	23.45	55.06	18.35	0.197	50	10	65	55	75	80	55.8	30	10	35	25	20	20	23.3
Y	28	M	AF	3	PS	3	NV	NV	FPS	10	Y	R	Y	AFG	16.71	17.12	19.5	53.33	17.78	14.46	13.84	14.38	42.68	14.23	0.2	20	5	5	35	15	0	13.3	5	5	5	5	0	0	3.33
Y	28	F	N	9	OTH	0	RA	NV	OTH	12	N	R	N	AFG	23.4	25.83	33.34	82.57	27.52	19.82	21.54	21.82	63.18	21.06	0.235	20	15	25	25	35	25	24.2	15	15	15	15	25	15	16.7
Y	28	M	N	4	PS	0	NV	NV	RAC	10	Y	R	Y	AFG	36.37	27.25	61.23	124.9	41.62	18	15.48	21.46	54.94	18.31	0.56	25	10	60	5	5	5	18.3	5	5	5	5	5	5	5
Y	25	M	A	4.5	PS	3	FR	NV	FPS	8	Y	R	Y	AFG	19.25	31.28	20.86	71.39	23.8	12.23	12.08	17.9	42.21	14.07	0.409	20	5	25	25	30	25	21.7	5	5	10	10	5	5	6.67
Y	35	M	AF	10	XB	3	IN	NV	OTH	30	Y	R	Y	AFG	14.02	14.38	19.9	48.3	16.1	8.36	15.91	14.81	39.08	13.03	0.191	10	10	10	35	25	10	16.7	10	10	10	10	10	10	10
Y	34	M	N	10	XB	0	RA	NV	ADV	10	N	L	Y	AFG	19.67	26.28	30.82	76.77	25.59	13.79	15.48	16.52	45.79	15.26	0.404	80	20	80	30	80	75	60.8	35	15	35	5	55	40	30.8
Y	37	F	AF	7	XB	3	IN	NV	ADV	14	Y	R	Y	AFG	30.13	35.17	32.45	97.75	32.58	18.12	16.02	23.45	57.59	19.2	0.411	45	45	60	40	60	50	50	20	15	15	15	15	5	14.2
Y	23	M	N	4	XB	3	RA	NV	FPS	23	Y	R	Y	AFG	19.33	16.07	22.24	57.64	19.21	12.68	12.84	13.91	39.43	13.14	0.316	40	80	80	35	80	80	65.8	35	35	50	85	80	25	51.7
Y	22	M	N	3	PS	3	FR	NV	FPS	16	Y	R	Y	AFG	14.68	15.74	19.04	49.46	16.49	13.24	21.22	24.06	58.52	19.51	-0.18	35	35	30	70	35	35	40	35	35	35	45	15	60	37.5
Y	28	M	N	7	XB	3	IN	RA	ADV	8	Y	R	N	AFG	19.84	25.01	24.24	69.09	23.03	17.82	19.49	22.43	59.74	19.91	0.135	35	35	40	70	45	20	40.8	35	35	40	70	45	20	40.8
Y	22	M	A	3.5	PS	3	RA	RA	FPS	7	Y	R	Y	RMC	18.45	18.25	22.05	58.75	19.58	13.38	12.73	12.53	38.64	12.88	0.342	55	15	45	50	35	70	45	30	0	20	25	5	5	14.2
Y	20	M	AF	1	XB	3	FR	NV	FPS	8	Y	R	Y	ADFA	13.93	19.73	17.94	51.6	17.2	10.61	9.24	12.07	31.92	10.64	0.381	5	5	30	15	65	80	33.3	0	0	15	5	50	0	11.7
Y	19	M	AF	0.66	PS	3	FR	RA	FPS	7	Y	L	Y	ADFA	16.04	17.17	21.01	54.22	18.07	12.74	13.34	15.38	41.46	13.82	0.235	10	0	70	30	65	50	37.5	10	0	50	20	5	35	20
Y	19	M	AF	2	PS	0	RA	RA	ADV	8	Y	R	Y	ADFA	18.87	26.27	28.86	74	24.67	16.37	20.18	18.68	55.23	18.41	0.254	30	30	30	60	45	5	33.3	5	5	15	25	15	0	10.8
Y	19	M	AF	0.75	PS	6	FR	NV	FPS	8	Y	R	Y	ADFA	19.85	18.39	29.59	67.83	22.61	12.71	14.04	14.84	41.59	13.86	0.387	60	30	60	75	85	80	65	35	30	40	20	25	30	30
Y	18	M	A	0.75	PS	0	RA	NV	ADV	16	Y	R	Y	ADFA	23.75	19.57	25.11	68.43	22.81	12.69	12.81	11.51	37.01	12.34	0.459	80	75	85	70	85	75	78.3	35	30	15	15	20	15	21.7
Y	21	M	N	4	PS	3	FR	RA	ADV	12	Y	R	Y	ADFA	19.48	20.6	38.98	79.06	26.35	12.84	15.8	23.93	52.57	17.52	0.335	65	50	65	40	60	40	53.3	45	35	30	20	25	35	31.7
Y	20	M	A	2.75	PS	3	RA	RA	FPS	13	Y	L	Y	ADFA	17.48	16.19	18.37	52.04	17.35	12.57	10.34	13.43	36.34	12.11	0.302	70	15	60	40	85	70	56.7	35	5	30	25	30	25	25
Y	21	M	A	2	PC	6	RA	FR	FPS	10	Y	R	Y	RMC	17.11	17.48	22.58	57.17	19.06	11.59	15.56	12.88	40.03	13.34	0.3	65	20	60	45	60	0	41.7	40	40	35	60	40	0	35.8
Y	22	M	A	3.5	PS	3	FR	RA	FPS	11	Y	R	Y	RMC	19.72	16.39	20.39	56.5	18.83	16.39	15.53	14.26	46.18	15.39	0.183	20	15	25	50	50	50	35	5	10	10	70	30	20	24.2
Y	21	M	A	3.5	PS	0	IN	RA	FPS	10	Y	L	Y	RMC	17.12	23.36	15.39	55.87	18.62	16.47	15.24	13.86	45.57	15.19	0.184	65	30	50	30	70	25	45	50	10	25	30	50	10	29.2
Y	24	M	A	0.75	PS	3	FR	FR	FPS	6	Y	R	Y	RMC	14.74	14.32	18.92	47.98	15.99	15.04	16.6	15.63	47.27	15.76	0.015	25	0	50	25	50	0	25	40	0	65	20	65	0	31.7
Y	23	M	A	0.33	XB	0	IN	RA	FPS	14	Y	R	N	RMC	17.15	23.92	21.24	62.31	20.77	17.29	25.04	20.64	62.97	20.99	-0.01	65	70	85	65	80	70	72.5	50	50	50	40	30	25	40.8
Y	23	M	A	0.33	XB	3	IN	NV	ADV	12	Y	R	Y	RMC	23.19	22.31	28.55	74.05	24.68	14.5	15.38	15.78	45.66	15.22	0.383	65	70	80	65	70	35	64.2	25	25	30	15	20	5	20
Y	25	M	A	0.33	PC	3	RA	NV	ADV	15	Y	L	Y	RMC	13.47	21.96	19.43	54.86	18.29	15.32	14.82	13.46	43.6	14.53	0.205	30	5	25	25	70	15	28.3	5	0	10	10	75	5	17.5
Y	26	M	A	0.33	XB	6	FR	RA	RTS	9	Y	R	Y	RMC	12.72	13.95	24.04	50.71	16.9	15	17.64	21.2	53.84	17.95	-0.06	10	20	40	20	20	10	20	10	15	35	20	15	10	17.5
Y	23	F	A	4.75	OTH	0	RA	NV	OTH		Y	R	Y	RMC	17.43	19.48	28.27	65.18	21.73	19.08	18.5	25.65	63.23	21.08	0.03	80	30	80	80	80	75	70.8	90	45	80	65	80	60	70
Y	29	M	A	0.33	XB	3	FR	NV	FPS	8	Y	R	Y	RMC	14.94	13.7	32.57	61.21	20.4	17.4	16.02	20.31	53.73	17.91	0.122	65	0	50	40	55	5	35.8	50	0	50	25	55	5	30.8
Y	26	M	A	0.33	PC	3	RA	RA	FPS	8	Y	R	N	RMC	15.85	21.5	21.53	58.88	19.63	21.03	19.95	16.48	57.46	19.15	0.024	45	15	60	55	65	20	43.3	30	10	45	55	60	15	35.8
Y	30	M	A	6.5	OTH	3	RA	NV	ADV	14	Y	R	Y	RMC	20.77	22.11	24.14	67.02	22.34	18.85	20.37	19.38	58.6	19.53	0.126	45	20	40	60	45	55	44.2	25	15	15	50	25	25	25.8
Y	26	M	A	6	XB	3	RA	RA	FPS	7	Y	R	Y	RMC	13.73	14.99	20.21	48.93	16.31	14.66	15.54	13.88	44.08	14.69	0.099	20	10	25	30	40	25	25	10	10	15	55	25	5	20
Y	27	M	A	9	PS	9	FR	RA	ADV	8	Y	R	Y	RMC	13.43	15.43	17.33	46.19	15.4	11.21	9.22	13.11	33.54	11.18	0.274	40	25	50	55	45	50	44.2	15	15	15	5	10	0	10
Y	21	M	A	4	PC	9	FR	NV	FPS	5	Y	R	Y	RMC	15.7	15.28	14.13	45.11	15.04	12.53	13.48	16.66	42.67	14.22	0.054	20	5	25	30	20	5	17.5	35	0	30	50	0	0	19.2
Y	21	M	A	1.9	PC	6	FR	IN	RTS	14	Y	R	Y	RMC	16.37	16.44	18.72	51.53	17.18	15.45	12.78	12.43	40.66	13.55	0.211	70	15	30	35	70	0	36.7	25	10	20	70	15	0	23.3
Y	19	M	A	0.9	PC	9	IN	NV	FPS	5	Y	R	Y	RMC	16.06	15.35	13.96	45.37	15.12	15.14	13.56	13.34	42.04	14.01	0.073	20	0	15	40	50	65	31.7	5	0	40	50	35	60	31.7
Y	20	M	A	1.5	PC	6	IN	RA	ADV	4	Y	L	Y	RMC	13.56	11.53	16.64	41.73	13.91	11.23	12.87	12.54	36.64	12.21	0.122	25	10	65	30	40	20	31.7	10	10	55	20	25	15	22.5
Y	21	M	A	4	PC	9	RA	NV	FPS	7	Y	L	Y	RMC	18.01	22.29	17.26	57.56	19.19	10.25	17.21	15.52	42.98	14.33	0.253	90	25	70	60	100	70	69.2	35	35	75	10	65	30	41.7
Y	23	M	A	1.75	XB	0	IN	NV	FPS	9	Y	R	Y	RMC	18.74	17.05	15.4	51.19	17.06	13.66	12.85	15.32	41.83	13.94	0.183	35	0	20	75	75	15	36.7	0	0	0	20	15	0	5.83
Y	21	M	A	1	PS	9	FR	RA	FPS	5	Y	L	Y	RMC	15.23	15.97	21.55	52.75	17.58	11.89	12.74	14.7	39.33	13.11	0.254	75	75	45	65	55	80	65.8	10	30	30	20	30	30	25
Y	25	M	A	1	PC	6	RA	NV	OTH	8	Y	R	Y	RMC	14.52	17.17	26.46	58.15	19.38	15.29	11.87	11.45	38.61	12.87	0.336	65	25	50	70	65	60	55.8	35	20	40	30	25	35	30.8
Y	22	M	A	3.5	XB	9	FR	RA	FPS	12	Y	R	N	RMC	14.75	17.54	18.64	50.93	16.98	11.73	14.46	13.39	39.58	13.19	0.223	65	30	75	40	80	80	61.7	55	20	65	65	55	55	52.5
Y	19	F	A	0.9	XB	0	RA	NV	FPS	6	N	R	Y	RMC	20.93	31.39	37.26	89.58	29.86	26.42	24.54	32.22	83.18	27.73	0.071	80	80	25	50	85	15	55.8	30	70	30	50	65	15	43.3
Y	27	M	A	0.25	PC	3	RA	NV	RTS	6	Y	R	Y	RMC	13.06	11.98	20.33	45.37	15.12	12.13	10.9	15.27	38.3	12.77	0.156	20	10	20	25	25	10	18.3	10	10	10	25	15	10	13.3
Y	28	M	A	0.9	PS	9	FR	NV	OTH	7	Y	R	N	RMC	16.08	13.55	16.75	46.38	15.46	11.27	12.83	18.07	42.17	14.06	0.091	25	35	30	50	60	55	42.5	10	15	20	25	15	15	16.7
Y	24	M	A	2	PS	6	IN	NV	RAC	16	N	R	Y	RMC	24.16	31.26	37.04	92.46	30.82	21.08	16.82	27.99	65.89	21.96	0.287	50	50	60	50	90	50	58.3	50	50	50	50	70	40	51.7
Y	23	M	A	5	PS	3	IN	RA	FPS	10	Y	L	Y	RMC	11.52	15.7	14.73	41.95	13.98	11.83	13.78	14.31	39.92	13.31	0.048	60	25	50	50	65	70	53.3	50	20	40	35	55	50	41.7
Y	23	F	A	0.75	XB	0	RA	NV	RAC	19	N	R	Y	RMC	18.76	26.27	39.27	84.3	28.1	25.02	21.21	22.01	68.24	22.75	0.191	80	80	65	35	75	65	66.7	55	55	55	15	55	50	47.5
Y	33	M	A	14	PS	0	NV	NV	RAC	15	N	R	Y	RMC	18.1	20.39	21.27	59.76	19.92	23.79	17.42	17.39	58.6	19.53	0.019	35	15	30	45	45	50	36.7	25	20	50	55	70	65	47.5
Y	20	M	A	1	PS	9	FR	NV	FPS	10	Y	R	Y	RMC	21.9	20.71	23.08	65.69	21.9	11.91	16.56	15.03	43.5	14.5	0.338	85	10	85	80	65	95	70	25	10	85	20	10	25	29.2
Y	31	M	A	3.5	XB	0	RA	NV	ADV	10	Y	R	Y	RMC	20.97	20.66	25.78	67.41	22.47	19.19	18.11	16.16	53.46	17.82	0.207	55	20	55	50	45	70	49.2	35	10	45	30	25	35	30
Y	22	M	A	3.5	PS	9	IN	NV	ADV	12	Y	R	N	RMC	12.71	17.21	21.58	51.5	17.17	14.06	12.06	10.29	36.41	12.14	0.293	35	15	40	20	40	30	30	20	20	20	10	15	5	15
Y	21	M	A	4	PC	9	IN	IN	RTS	2	Y	R	Y	RMC	23.22	28.02	26.73	77.97	25.99	16.77	15.29	19.33	51.39	17.13	0.341	85	75	95	65	85	75	80	20	10	15	5	15	10	12.5
Y	19	M	A	11	PS	9	FR	NV	ADV	6	Y	R	Y	RMC	19.77	17.49	25	62.26	20.75	17.11	20.69	16.45	54.25	18.08	0.129	50	25	70	35	60	60	50	50	25	70	25	60	60	48.3
Y	27	M	A	1	XB	3	RA	NV	FPS	8	Y	R	Y	RMC	11.59	13.56	19.73	44.88	14.96	12.51	12.69	13.75	38.95	12.98	0.132	35	10	45	60	45	35	38.3	10	10	20	20	10	15	14.2