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**H-60A/L Cargo Compartment Ingress and Egress Evaluation
of Current and Prototype Troop Seating**

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Interim Report**

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14. ABSTRACT Ingress and egress evaluation of both current and prototype H-60A/L rotorcraft troop seating was completed by 711HPW/RHCP and performed at HX-21 Squadron, Naval Air Warfare Center Aircraft Division, Patuxent River, MD on December 2011. The H-60A/L troop seat, a prototype all-fabric troop seat by Glatz Aeronautical, and a prototype seat by Wolf Technical Services were tested. Ten examples of each seat were installed in a MH-60S rotorcraft per seat configuration, and multiple ingress and egress trials were performed by Marines from Marine Corp Base Quantico, VA outfitted in battle gear. Ingress and egress times were averaged and compared using a one-way ANOVA to determine statistical differences between seats. The H-60A/L seat had a statistically significant lower ingress time compared to the Glatz and Wolf seats. The H-60A/L seat had a statistically lower egress time from the Wolf seat, though no difference was shown between the H-60A/L and Glatz seats as well as the Glatz and Wolf seats. Whether or not these differences are operationally significant is beyond the scope of this study.					
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1.0 OVERVIEW

The Applied Neuroscience Branch under the 711 Human Performance Wing (HPW) completed a research effort performed at HX-21 Squadron, Naval Air Warfare Center Aircraft Division, Patuxent River, MD to assess the ingress and egress efficiency of both current and prototype H-60 rotorcraft troop seating. A total of three seat configurations were evaluated: the H-60A/L troop seat; a prototype all-fabric troop seat by Glatz Aeronautical; and a prototype seat by Wolf Technical Services. Ten seats of each type were installed in a MH-60S rotorcraft, and multiple ingress and egress trials of each configuration were conducted using Marines from Marine Corp Base Quantico, VA outfitted in battle gear. Ingress and egress times were averaged and compared using a one-way Analysis of Variance (ANOVA) to determine statistical differences between seats.

2.0 INTRODUCTION

Operational efficacy of using troop seats with side panels has been questioned with respect to egress and accommodation of personnel. Anecdotally, seats with side panels, such as the UH-60M troop seat, could cause a 'snag hazard', impeding ingress or egress from the aircraft in a combat scenario. This raises the possibility that different seat designs, either wider or in a different configuration or both, could mitigate this issue.

711 HPW/RH has a Memorandum of Agreement (MOA) with the Defense Safety Oversight Council (DSOC) and Office of the Secretary of Defense (OSD), Deputy Director, Live Fire Test to perform comparative seat testing to evaluate occupant safety in a crash environment. OSD recommended an additional effort to conduct a comparative ingress and egress assessment of several of the seat configurations prior to their destructive use in dynamic seat testing.

The ingress and egress comparative testing provides a simple methodology to quickly baseline and compare different seat designs. This methodology also allows seating to be tested independent of their airframes and can be used for the basis of performance testing prior to acquisition decisions being finalized. The testing was not intended to answer all questions related to helicopter ingress and egress since conditions such as aircraft configuration, personnel size, shape, and gear used, and even the developmental nature of the seats tested were limited in scope. In addition the testing was part of a research effort and not part of an acquisition program. The objective of this testing was to provide generalized knowledge of different seat designs and their relative effect on aircraft ingress and egress.

3.0 METHOD

3.1 Evaluation Setup

Evaluation was performed at the HX-21 Squadron, Naval Air Warfare Center Aircraft Division, Patuxent River, MD. Trials were conducted by 711HPW/RHCP personnel and supported by OSD, seat manufacturers, and HX-21 personnel. A series of tests timing ingress and egress of military personnel in combat gear was conducted with multiple seat types. Each seat type was assessed multiple times to allow for statistical analysis.

3.2 Aircraft

A MH-60S aircraft was used for the evaluation. Modification to the aircraft cabin was limited as the aircraft was actively being flown during the day. An extra fuel tank was installed in the rear of the cabin, preventing installation of the back row of forward facing seats. A line 15 feet parallel to the cabin doors was marked outside the aircraft and was used as the starting point/time start ($t=0$ seconds) for ingress and the time stop point for the egress from the aircraft.

3.3 Seats

A total of three different seats were evaluated for ingress and egress times, and are identified below. Ten (10) samples of each of the three seat types were installed in the aircraft for each trial. Four seats were installed in the aft-facing position, three in the forward-facing position, two in the side-facing crewmember positions, and one between the side-facing seats. Last row/forward facing seats were not installed in the aircraft cabin due to the additional fuel tank. A layout of the interior of the aircraft is shown in Figure 1.



Figure 1. Layout of Interior of MH-60S Aircraft

3.3.1 H-60A/L Seat

The H-60A/L seat is the standard troop seat currently installed in most H-60 rotorcraft. It is a fabric seat with an aluminum tubing structure that has attachment points at the top and bottom of the seat. Energy attenuation is by wire benders, and the seat does not have side supports. The seat has a backpack 'pouch' that is accessible through a Velcro seat back. For this evaluation the backpack pouch was not used. The seat is shown in Figure 2.



Figure 2. H-60A/L Fore and Aft seats

3.3.2 Glatz Aeronautical Seat

The Glatz Aeronautical (Newtown, PA) seat is a variant of their previously designed all-fabric seat developed through an Air Force Research Laboratory (AFRL) Phase I Small Business Innovative Research (SBIR) program for H-60 rotorcraft. The seat hangs from top mounts with webbing straps attaching the seat to the floor to prevent swing. The seat is unconventional relative to currently used troop seats in that it has limited hard structure and incorporates a large foam seat pan for energy attenuation during impact or crash. The seat uses a Pacific Scientific-made 4-point restraint. The seat has fabric side supports. The seat is shown in Figure 3.



Figure 3. Glatz Aeronautical Prototype Troop Seat

3.3.3 Wolf Technical Seat

The Wolf Technical Services (Indianapolis, IN) prototype seat was also developed through an AFRL SBIR program. The seat tested has a fabric seat pan and seat back with a friction brake as an energy attenuator. The brake does not engage unless a certain acceleration level is obtained during a hard landing or crash event. The attenuator is reusable, and the seat was specifically manufactured to test how well the technology would protect an occupant during a crash event. Installation of multiple seats in one aircraft was not initially considered in this prototype version, and because of this, there was difficulty installing multiple seats side by side in the H-60 aircraft. All seats were attached to their respective top mounts, but not all seats were installed into hard points on the floor. When this occurred the respective seat was attached to an adjacent seat. The seats were rigid enough for the ingress and egress evaluation, though modification to the seat will be required. The seat is shown in Figure 4.



Figure 4. Wolf Technical Services Prototype Seat

3.4 Volunteers

A total of eleven Marine volunteers from Marine Corp Base Quantico, VA participated in this study. Volunteers were instructed to dress in battle-ready dress which consisted of a BDU, body armor, a backpack partially loaded with gear of their choice, a helmet, and a simulated rifle as seen in Figure 5. Ten volunteers were used for each trial of each seat. One volunteer was randomly selected to sit-out of each trial. The Marines did not have previous rotorcraft experience prior to this evaluation. Their specifications are shown below in Table 1.



Figure 5. Test Volunteer Battle Configuration

Table 1. Volunteer Marine Specifications

Subject Number:	Age (yrs):	Time in Service:	Height (in):	Weight (lbs):	Weight with Gear (lbs):
P1	21	18-Oct-09	72	157	204
P2	23	12-Sep-08	72	184	220
P3*	19	19-Sep-10	60	131	154
P4	25	6-Jun-06	73	213	252
P5	28	2-May-05	69	183	217
P6	20	11-Nov-09	66	154	195
P7	19	25-Oct-10	69	167	194
P8	22	10-Jun-07	68	150	185
P9	26	8-Dec-08	70	169	200
P10	25	9-Aug-06	66	170	212
P11	22	11-Aug-08	67	155	184

*P3 was a pregnant female Marine.

3.5 Instrumentation

711HPW/RHCP test conductors used a stopwatch to record the time for subjects to ingress or egress the aircraft with the reference start and stop point set 15 ft from the aircraft side entrance. For ingress trials the time to ingress was stopped when all volunteers had provided a visual sign when they were fully strapped into the seat. For egress trials the time to egress was stopped when all subjects had exited the aircraft and crossed the reference stop point outside the aircraft.

4.0 PROCEDURES

All of the seats were installed into the H-60 aircraft by Navy personnel with assistance from the AFRL test conductor personnel and any seat manufacturer representatives that were in attendance for their respective seats. The legacy H-60A/L seat was tested first followed by Glatz and then Wolf. A brief survey was given to each Marine volunteer following testing of each seat to record some background information on each volunteer as well as their thoughts on each type of seat. A copy of the survey is located in Appendix A.

4.1 Ingress Evaluation

For the ingress evaluation, the test volunteers were instructed to stand behind a reference start/stop line that was 15 feet parallel to the side cabin doors as shown in Figure 6. At t=0, the volunteers ran to and entered the aircraft cabin from both sides of the aircraft and sat in a troop seat. Seats were not assigned prior to ingress testing. Volunteers subsequently strapped themselves into the test seats as shown in Figure 7. When complete, the volunteers gave a visual sign that they were completely strapped in. The 711HPW/RHCP test conductors recorded the change in time between the start of ingress at 15 feet from the aircraft and the completion of ingress when all volunteers were completely strapped in. A practice session was provided prior

to the start of the time trials for each volunteer to become familiar with the seat and operation of its restraint harness for each seat type.



Figure 6. MH-60S Aircraft and Relative Position to Reference Start/Stop Point



Figure 7. H-60 Aircraft Loaded with Volunteers

4.2 Egress Evaluation

For the egress evaluation, the volunteers were instructed to strap themselves into their pre-designated troop seats. When all the volunteers were properly strapped in with the harness tightened, they were given a signal to un-strap themselves, exit from each side of the aircraft, and proceed to the reference stop point. The 711HPW/RHCP test conductors recorded the change in time between the start of egress from the seat to the completion of egress when all volunteers had exited the aircraft and were located beyond the reference stop point 15 feet tangential to the cabin doors.

5.0 RESULTS AND DISCUSSION

5.1 Time Trials

Nine trials for ingress and egress were performed for each type of seat. It was assumed prior to the evaluation that there may be training effects. Figure 8 show the ingress and egress times for each trial of each seat. From the data it is confirmed there are some training effects for each seat. This is most evident in the egress evaluation with the H-60A/L seat where the egress times were cut in half after the first two trials. These two trials were not included in the statistical analysis. To account for any fatigue or mental effects, the last two trials were not included in the statistical analysis. Data from the last two trials did not appear to be as consistent as the middle five trials included in the analysis. Appendix B includes the individual test list.

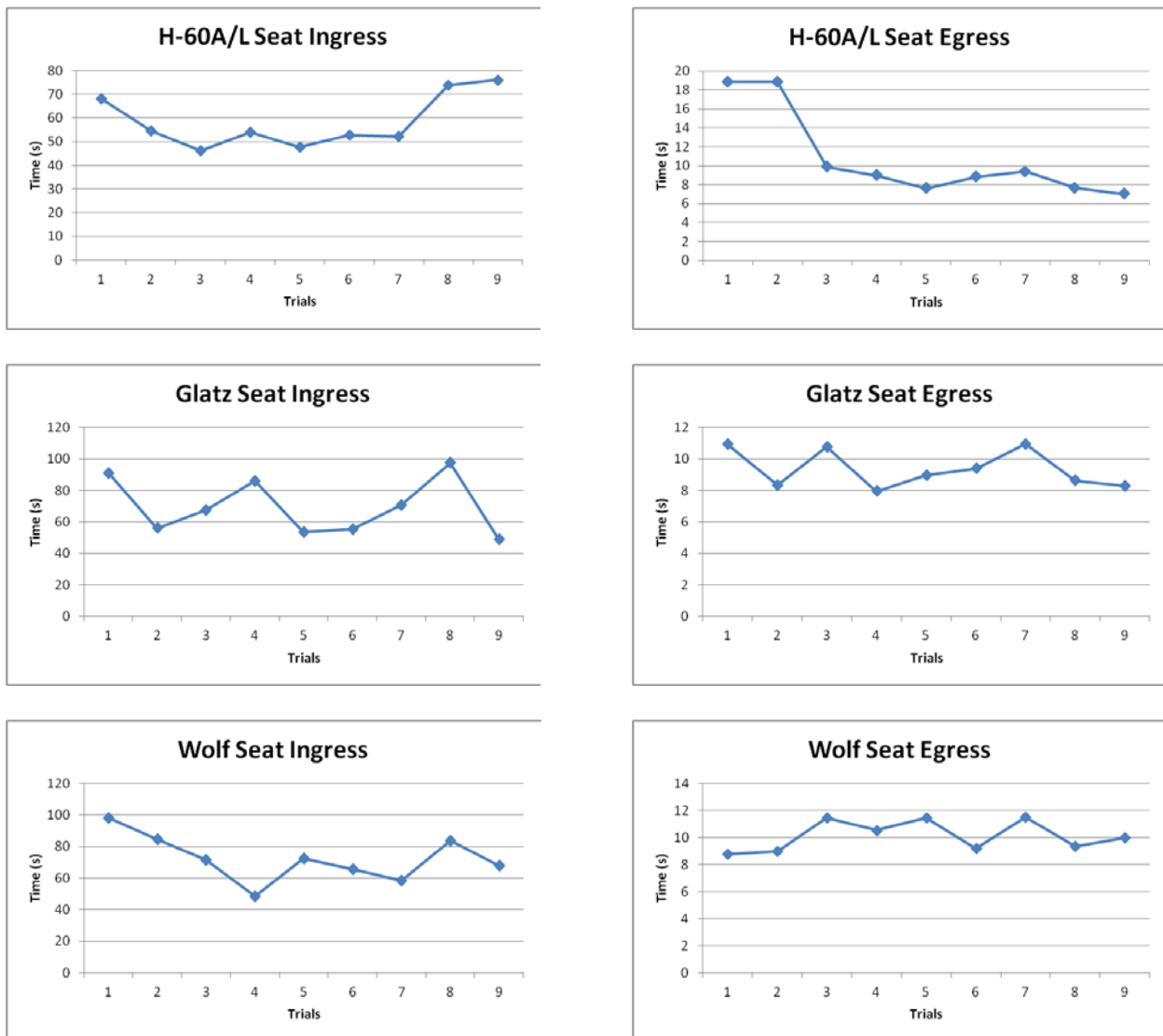


Figure 8: Individual Seat Trial Times (seconds)

Figure 9 shows the average ingress times of each seat type for the middle five trials (trials 3-7). The error bands are the standard error for each data set of each seat. The H-60A/L seat had the lowest average ingress time of 50.60 seconds. The Glatz seat had the highest average ingress time of 66.67 seconds, and the Wolf seat had an average ingress time of 63.42 seconds.

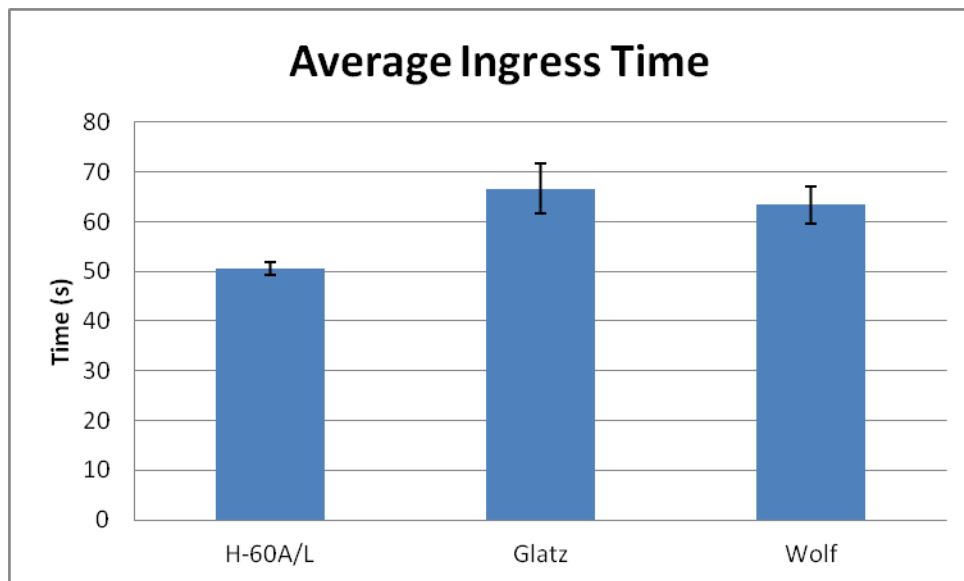


Figure 9. Average Ingress Time with Standard Error

To determine if the differences in the ingress times among the three seat types were statistically significant, a one-way ANOVA was performed. Table 2 lists the p-values. The ingress times for the H-60A/L seat were significantly lower ($p < 0.05$) than the ingress times for the Glatz and Wolf seats with p-values of 0.029289 and 0.026434 respectively. The ingress times for the Glatz and Wolf seats were not statistically different.

Table 2. P-values Between Seats Ingress Times

	Glatz	Wolf
H-60A/L	0.029289	0.026434
Glatz	x	0.670655

Figure 10 shows the average egress times of each seat type for the middle five trials (trials 3-7). The error bars are the standard error for each data set of each seat. The H-60A/L seat had the lowest average egress time of 8.94 seconds. The Wolf seat had the highest average egress time of 10.81 seconds. The Glatz seat had an average egress time of 9.60 seconds.

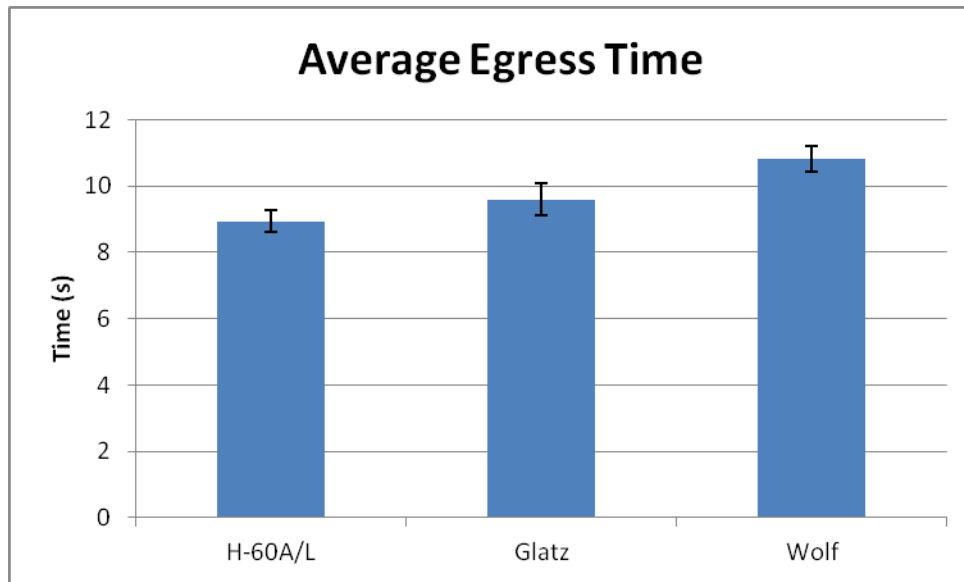


Figure 10. Average Egress Time with Standard Error

To determine if the differences in the egress times among the three seat types were statistically significant, a one-way ANOVA was performed to compare the data sets. The p-values are listed in Table 3. The egress times for the H-60A/L seat were significantly lower ($p < 0.05$) than the egress times for the Wolf seat with a p-value of 0.012569. Egress times between the H-60A/L and Glatz seats as well as between the Glatz and Wolf seats were not significant.

Table 3. P-values Between Seat Egress Times

	Glatz	Wolf
H-60A/L	0.353833	0.012569
Glatz	x	0.130377

5.2 Subject Survey

A survey was given to each volunteer after each seat's trials to give a subjective evaluation of the seats. A copy of the survey is located in Appendix B. The survey consisted of four questions as well as space for the volunteer to add additional comments. The questions consisted of a rating scale from 1 to 5, with 1 being poor and 5 being excellent. Average results of the eleven subjects are presented in Table 4.

Table 4. Survey Average Results

	H-60A/L	Glatz	Wolf
Ease of Ingress:	3.09	3.27	2.45
Ease of Egress:	4.00	4.27	2.64
Ease of Attachment of Restraint:	2.36	3.18	2.45
Comfort of Seat:	3.45	4.64	2.91

*scale: 1 = Poor to 5 = Excellent

Subjects on average determined that the Glatz seat was the easiest to ingress the rotorcraft while the Wolf seat was the most difficult. Quantitatively, the H-60A/L seat was the fastest seat to ingress while the Glatz seat was the longest, so subjective ratings did not correlate well to objective times. Most of the subjects commented that on all seats it was difficult to find and buckle into the restraint belts. For the Wolf seat, a common comment was that the restraint belts were too long and that the seat was difficult to get into. Also for the Wolf seat, the seat bucket was higher than the other seats which caused the Marines' heads to touch the ceiling of the cabin.

Volunteers rated the Glatz seat easiest to egress. The Glatz seat had a slightly higher average egress time than the H-60A/L, though the differences were not statistically significant. One consistent comment on the Glatz seat was that it was easy to egress, though the seat pan cushion would sometimes pop out. This issue would require a simple change to the seat design such as the addition of a strap or Velcro.

Volunteers on average rated the Glatz restraint to be the easiest to buckle. Comments were mixed with some volunteers liking the seat restraint while others not liking them at all. P2 commented that the Glatz lap belts were hard to grab and tighten due to the side panels.

Volunteers on average rated the Glatz seat the most comfortable. This is not surprising as both the H-60A/L and Wolf seats had much more rigid seat pans than the Glatz seat. Also, the Glatz seat does not have any hard points on the seat pan like the H-60A/L and Wolf seats. It is noted that this is short term comfort and may or may not reflect long term comfort of the seat.

6.0 CONCLUSION

Three different troop seat designs were evaluated for ingress and egress efficiency from a MH-60S rotorcraft. The H-60A/L seat was the baseline seat as it has been used in operational aircraft for 30+ years. The Glatz and Wolf seats were prototypes designed to address some of the perceived operational issues with the H-60A/L seat such as long-term comfort, increased occupant size, seat weight, and advances in materials and energy attenuation technology. The

testing performed by 711HPW/RHCP is a snapshot of ingress and egress times for these different seat types given testing constraints such as aircraft configuration and personnel gear worn by volunteers. The seat ingress time of the H-60A/L seat was statistically lower than the prototype Wolf and Glatz seats. It is doubtful this is due to previous familiarity with the seat since the volunteer had no previous experiences with the H-60A/L seat. Subjective survey results suggested that the Glatz seats would have been easier to enter and strap in, although this finding does not correlate with the objective ingress time data. The H-60A/L egress time was statistically lower than the Wolf seat though not statistically different from the Glatz seat. The average spread between the H-60A/L and Wolf seats was only ~2seconds. For both ingress and egress times of the seats, it is noted that statistical significance may or may not correlate with operational significance. Operational significance is beyond the scope of this program and cannot be determined by 711HPW/RHCP.

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Appendix A Volunteer Survey

Name:	Seat:
Age:	Time in Service:
Height:	Weight:

For each item identified below, circle the number to the right that best fits your judgment of its quality. Use the scale above to select the quality number.

Description/Identification of Survey Item	Scale				
	P O O R	2	3	4	E x c e l l e n t
1. Ease of Ingress	1	2	3	4	5
2. Ease of Egress	1	2	3	4	5
3. Ease of attachment of Restraint	1	2	3	4	5
4. Comfort of seat	1	2	3	4	5

General Comments:

Appendix B Individual Test List

Test Date	Cell:	Test Number	Seat	Ingress/Egress	Time	Temp (F)	Delta Time (s)	Subject Sit Out	Notes
5-Dec	A	1	H-60A/L	Ingress	1745	62	68.19	p3	
5-Dec	A1	2	H-60A/L	Egress	1750	62	18.88	p3	
5-Dec	A2	3	H-60A/L	Ingress	1800	62	54.53	p5	
5-Dec	A3	4	H-60A/L	Egress	1805	62	18.85	p5	
5-Dec	A4	5	H-60A/L	Ingress	1810	68	46.11	p3	
5-Dec	A5	6	H-60A/L	Egress	1815	68	9.89	p3	
5-Dec	A6	7	H-60A/L	Ingress	1820	66	54.07	p11	
5-Dec	A7	8	H-60A/L	Egress	1830	66	8.96	p11	
5-Dec	A8	9	H-60A/L	Ingress	1838	66	47.67	p2	
5-Dec	A9	10	H-60A/L	Egress	1840	66	7.63	p2	
5-Dec	A10	11	H-60A/L	Ingress	1850	66	52.85	p8	
5-Dec	A11	12	H-60A/L	Egress	1855	66	8.84	p8	
5-Dec	A12	13	H-60A/L	Ingress	1855	66	52.29	p3	
5-Dec	A13	14	H-60A/L	Egress	1905	66	9.38	p3	
5-Dec	A14	15	H-60A/L	Ingress	1915	65	73.87	p3	
5-Dec	A15	16	H-60A/L	Egress	1920	65	7.66	p3	
5-Dec	A16	17	H-60A/L	Ingress	1925	65	76.09	p7	
5-Dec	A17	18	H-60A/L	Egress	1930	65	7.02	p7	
5-Dec	B	19	GLATZ	Ingress	2015	61	90.96	p4	
5-Dec	B1	20	GLATZ	Egress	2020	61	10.93	p4	Seat cushion 6&3 cushion out
5-Dec	B2	21	GLATZ	Ingress	2027	61	56.06	p8	Seat 7 cushion out, Seat 10 rear leg out
5-Dec	B3	22	GLATZ	Egress	2035	63	8.35	p8	
5-Dec	B4	23	GLATZ	Ingress	2043	63	67.69	p3	Seat 10 cushion out

5-Dec	B5	24	GLATZ	Egress	2047	63	10.76	p3	
5-Dec	B6	25	GLATZ	Ingress	2055	63	86.02	p9	
5-Dec	B7	26	GLATZ	Egress	2100	63	7.96	p9	
5-Dec	B8	27	GLATZ	Ingress	2105	63	53.65	p1	
5-Dec	B9	28	GLATZ	Egress	2112	63	8.96	p1	
5-Dec	B10	29	GLATZ	Ingress	2116	63	55.4	p7	
5-Dec	B11	30	GLATZ	Egress	2120	63	9.4	p7	
5-Dec	B12	31	GLATZ	Ingress	2125	63	70.59	p2	
5-Dec	B13	32	GLATZ	Egress	2135	63	10.94	p2	
5-Dec	B14	33	GLATZ	Ingress	2140	63	97.59	p9	
5-Dec	B15	34	GLATZ	Egress	2146	63	8.63	p9	
5-Dec	B16	35	GLATZ	Ingress	2150	63	49	p11	
5-Dec	B17	36	GLATZ	Egress	2155	63	8.28	p11	
6-Dec	C	37	WOLF	Ingress	1508	68	98.03	p4	
6-Dec	C1	38	WOLF	Egress	1510	68	8.75	p4	
6-Dec	C2	39	WOLF	Ingress	1520	65	84.83	p9	Subject head
6-Dec	C3	40	WOLF	Egress	1525	65	9	p9	Subject feet
6-Dec	C4	41	WOLF	Ingress	1530	65	71.65	p8	
6-Dec	C5	42	WOLF	Egress	1535	65	11.43	p8	Seat 1 head
6-Dec	C6	43	WOLF	Ingress	1538	65	48.69	p2	
6-Dec	C7	44	WOLF	Egress	1544	65	10.53	p2	Belt flip over
6-Dec	C8	45	WOLF	Ingress	1548	65	82.73	p2	Leg touch
6-Dec	C9	46	WOLF	Egress	1555	65	11.43	p2	
6-Dec	C10	47	WOLF	Ingress	1600	65	65.53	p5	
6-Dec	C11	48	WOLF	Egress	1605	61.5	9.17	p5	
6-Dec	C12	49	WOLF	Ingress	1620	64	58.6	p8	
6-Dec	C13	50	WOLF	Egress	1630	64	11.51	p8	
6-Dec	C14	51	WOLF	Ingress	1635	64	83.82	p5	
6-Dec	C15	52	WOLF	Egress	1641	63	9.35	p5	

6-Dec	C16	53	WOLF	Ingress	1645	63	68.04	p1	
6-Dec	C17	54	WOLF	Egress	1650	64	9.97	p1	

ACRONYMS

711HPW	711 th Human Performance Wing
AFRL	Air Force Research Laboratory
ANOVA	Analysis of Variation
DSOC	Defense Safety Oversight Council
MOA	Memorandum of Agreement
OSD	Office of the Secretary of Defense
SBIR	Small Business Innovative Research