

AD-A243 496



Report No. NADC-91071-60



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**AIRCREW CRITIQUE OF HIGH-G CENTRIFUGE
TRAINING: PART III. - "WHAT CAN WE CHANGE
TO BETTER SERVE YOU?"**

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11 JUNE 1991

FINAL REPORT
Period Covering October 1988 to May 1991

Approved for Public Release; Distribution is Unlimited

91-17919



Prepared for
Air Vehicle and Crew Systems Technology Department (Code 602C)
NAVAL AIR DEVELOPMENT CENTER
Warminster, PA 18974-5000

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REPORT DOCUMENTATION PAGE			Form Approved OMB No 0704-0188	
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1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE 1991 June 11	3. REPORT TYPE AND DATES COVERED Final 10/88 to 5/91	
4. TITLE AND SUBTITLE AIRCREW CRITIQUE OF HIGH-G CENTRIFUGE TRAINING: PART III. "WHAT CAN WE CHANGE TO BETTER SERVE YOU?"			5. FUNDING NUMBERS	
6. AUTHOR(S) James E. Whinnery, Ph.D., M.D.; Richard J. Hamilton, M.D., LT USNR MC (FS)				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Vehicle and Crew Systems Technology Department (Code 602C) NAVAL AIR DEVELOPMENT CENTER Warminster, PA 18974-5000			8. PERFORMING ORGANIZATION REPORT NUMBER NADC-91071-60	
9. SPONSORING MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Vehicle and Crew Systems Technology Department (Code 602C) NAVAL AIR DEVELOPMENT CENTER Warminster, PA 18974-5000			10. SPONSORING MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION AVAILABILITY STATEMENT Approved for Public Release; Distribution is Unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum length 200 words) We have successfully initiated centrifuge high-G training for fighter-attack aviators at the Naval Air Development Center. The response of aircrew to a post-training critique question asking how the program could be modified to better meet operational needs was evaluated so aircrew might have the ability to improve <u>their</u> training program. The recommendations could be grouped into 5 major categories: (1) no change, (2) addition of a closed-loop aerial combat maneuvering (ACM) profile with bogey on a tracking task, (3) centrifuge gondola modifications, (4) training profile modifications, and (5) modifications concerning when the training is given. A number of suggestions for improvement are worth pursuing and implementing immediately. Although caution should be exercised when altering the content and goals of the proven successful program, we strongly concur with several of the changes. This includes providing a closed-loop ACM profile with at least a moderately high-fidelity tracking task (bogey) and at least optional "G-LOC training."				
14. SUBJECT TERMS Aircrew Training Centrifuge Fighter Aviation			15. NUMBER OF PAGES 16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT	

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ABSTRACT

We have successfully initiated centrifuge high-G training for fighter-attack aviators at the Naval Air Development Center. The response of aircrew to a post-training critique question asking how the program could be modified to better meet operational needs was evaluated so aircrew might have the ability to improve their training program. The recommendations could be grouped into 5 major categories: (1) no change, (2) addition of a closed-loop aerial combat maneuvering (ACM) profile with bogey on a tracking task, (3) centrifuge gondola modifications, (4) training profile modifications, and (5) modifications concerning when the training is given. A number of suggestions for improvement are worth pursuing and implementing immediately. Although caution should be exercised when altering the content and goals of the proven successful program, we strongly concur with several of the changes. This includes providing a closed-loop ACM profile with at least a moderately high-fidelity tracking task (bogey) and at least optional "G-LOC training."

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INTRODUCTION

The aircrew high-G centrifuge training program instituted by the U.S. Air Force for its Tactical Air Command fighter crews was very successful (1). The centrifuge training initiated at the Naval Air Development Center (NADC) utilized the same template for training naval fighter-attack aviators. This was done for several reasons: (1) proven acceptability by aircrew, (2) capability of accomplishing similar training with the existing facilities, and (3) proven acceptable safety for accomplishing aircrew training using this template. The most rapid implementation possible was also an extremely important consideration, since everyday naval aviators continue to engage in aerial combat. Without a maximally perfected anti-G straining maneuver (AGSM), which could be developed with the centrifuge training program, we considered flight safety and optimum mission accomplishment to be degraded each day the training was delayed. We sought to initiate the training using the existing template with the desire to improve the program continuously in every way possible, especially to customize the U.S. Air Force template to more specifically meet the operational needs of Navy and Marine fighter-attack aviators.

We have previously described the questionnaire (Appendix I) administered to aircrew trainees following completion of the training (2,3). We specifically asked each trainee "What can we change to better serve you?" to provide aircrew an opportunity to have direct input to improve their own program to meet their operational needs. The purpose of this manuscript is to review the response of 515 of the total 525 aircrew following their high-G training at NADC.

"WHAT CAN WE CHANGE TO BETTER SERVE YOU?"

Based on the extremely favorable critiques, we have not included all the laudatory comments but only the comments which contained insight into potential changes that might be effected. The following discussion must be carefully reviewed within the context of the other reports describing aviator responses to the other parts of the critiques (2,3). Many aspects of potential program modification can be gleaned from responses to other critique questions.

Appendix II lists the substantive comments provided by aircrew that could be used to modify the existing program or further strengthen various aspects of the program. Since we have a dynamic program, changes were made continuously as they were suggested by aircrew. Review of the responses revealed 5 major areas of concern expressed by the aircrew completing the centrifuge training as summarized in Table I. It was gratifying that a number of aircrew considered the program perfect in its current format. As previously reviewed from the responses concerning what aircrew considered the best part of the training program (2,3), many aircrew responded in a similar fashion expressing complete satisfaction with the current format. There was considerable concern expressed that adverse changes to alter the focus and concepts of the program might be allowed to occur. The recommendation for no change was therefore one of the 5 major points expressed by aircrew. The remaining four points concerned modifications to the centrifuge gondola, modifications to the centrifuge profiles, changes concerning when aircrew should go through the training, and a strong request for an aerial combat maneuvering profile with visuals to enable tracking a bogie aircraft.

There were a large number of "nothing" responses to this question (comment number 33 was included as an example) which were not included in Appendix II. We were gratified by these responses and those like comment number 4 from a 29 year old F-14 pilot: "If it works don't fix it"; comment number 61 from a 33 year old A-7E pilot: "If it ain't broke don't monkey with it - keep as is"; comment number 111 from a 39 year old F-16 pilot: "Tough to improve on a good program"; and comment number 13 from a 26 year old F-14 non-flying officer (NFO): "Relocate to El Toro, California." All of these confirm the existing program format is viewed as extremely favorable by aviators.

Above all, there is no question that the aircrew want to "fly" the centrifuge against a maneuvering

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"bogie" aircraft presented with at least a moderate degree of fidelity visual tracking task. There are separate issues associated with such a recommendation including the aerial combat maneuvering (ACM) profile, the pilot trainee centrifuge controlled flight (closed-loop centrifuge control), and the link to a visual tracking task which includes a "bogie." Although we did not provide an ACM profile to the trainees, they were given full closed-loop control on all rapid onset profiles and a visual tracking task that included a non-maneuvering (except for increased +G_y) bogie. We have developed the capability to provide a wide-field-of-view (WFOV) tracking task which includes a bogie such that the pilot trainee can track a bogie flying an ACM profile taken from actual aerial combat maneuvering instrumentation (ACMI) flight (4). Such profiles have been defined as aerial combat environment simulation (ACES). Aviators have responded very favorably to this system when it has been utilized during centrifuge training. We have unfortunately not been able to provide it on a routine basis, but certainly it meets (or exceeds) all aviator expectations for such a closed-loop ACM profile against a maneuvering bogie. The desire to have an ACM profile is reflected by comment number 60 from a 37 year old F-16 pilot: "Later on add an air combat profile"; comment number 81 from a 39 year old A-7 pilot: "Add an ACM profile"; comment number 82 from a 38 year old A-7E pilot: "A simulated ACM engagement with variable G environment"; and comment number 83 from a 29 year old A-7E pilot: "ACM." The desire for the bogie on a visual tracking task is evidenced by comment number 57 from a 26 year old F/A-18 pilot: "Much better with video in centrifuge, improved video could get 'heart pumpin' and fangs out"; comment number 51 from a 29 year old F-14A+ pilot: "Tail chase video"; comment number 67 from a 25 year old F/A-18 pilot: "Good ACM visuals"; comment number 76 from a 25 year old F-14 pilot: "More visuals in ball; more pilot control of G-onset"; comment number 98 from a 29 year old AV-8B pilot: "Perhaps some type of concentration tasks (monitor altitude, airspeed, track simulated bogey)"; comment number 117 from a 27 year old F-14 pilot: "Try to simulate dog fights"; and comment number 140 from a 25 year old F-14 pilot: "Run chasing a bogey on a screen - so that you focus on trying to hose his brains out while trying to hook." It should be noted that the need for such video-tracking is not a universal request (nothing for the aircrew seems to be 100%); comment number 55 from a 38 year old F-16 pilot: "Training was good enough that increased display capability might not add significantly"; comment number 58 from a 31 year old A-6 pilot: "HUD tracking would be nice although for non HUD aviators it may be more of a distraction. Emphasis should be on G-awareness/anti-G straining maneuver"; and comment number 78 from a 25 year old F-14A pilot: "I do not feel that improvements to cockpit are necessary for 2 reasons: 1. Making the trainer a 'dog fight G trainer' when you would look all around the cockpit to track a bogie would be great if the opportunity to use it on a routine basis existed. It doesn't however; 2. When pulling +6G's engaged with a bogie you will not be looking at consoles, pushing buttons, etc." These are excellent points relative to an attempt for actual recreation of aerial combat flight. We agree very strongly with comment number 104 from a 27 year old F/A-3 pilot: "I can see an addition of more tactical cockpit tasking during G. It would be interesting to see what level of cockpit task saturation would begin to erode G-tolerance ... targeting, problems, missile breaks, etc." This is a critically important goal for future G-training program development. It should be attacked on a priority basis. This developmental work should include investigation of such comments as number 120 from a 29 year old AV-8B pilot: "Put a bogey on screen to analyze performance during G and G-LOC"; and comment number 130 from a 28 year old F-14 pilot: "Make one run pilot controlled with pilot pull until grey 'working' limit." These suggestions should be evaluated immediately. They have the promise to make the first real quantum leap to improve centrifuge high-G training.

A significant number of suggestions to improve the configuration of the centrifuge gondola were made. This includes making the general gondola configuration more aircraft-like in as many ways as possible to specific alterations of the seat, rudder pedals, stick/throttle, arm rests, and abort switches. Perhaps the major point concerning making the gondola aircraft specific is the placement of the stick. A significant number of aircrew who fly with a center-stick desire this configuration as opposed to a force sensing side-stick controller. The training is certainly very demanding physically. Adequate air conditioning and water in the gondola were high priorities; comment number 139 from a 27 year old F-14 radar intercept officer (RIO): "Centrifuge was a might toasty"; and comment number 47 from a 39

year old F-4E pilot: "I would have killed for a squirt of water." Overall, even though the gondola configuration is not the major concern of aircrew during the training, we can certainly continue to address the various recommendations of the aircrew to better serve them. This requires funding to make these changes and subsequently transition the improvements to the training program, an important step that has not been addressed.

The centrifuge training profiles were generally very acceptable to aircrew. Every profile was mentioned by at least one aviator as being the best part of the program (2). The gradual onset run (training profile number 1) is the only real measure of $+G_z$ -level tolerance and it does provide some information on $+G_z$ -cardiovascular tolerance (5). Although some investigators have sought to relate the responses of aircrew during centrifuge training to "operational tolerance", this is not possible with the current centrifuge training program (10). This run also provides nearly every aviator the opportunity to experience his initial limiting neurologic symptoms associated with altered vision (greyout to blackout). The run also provides an opportunity for muscular/physiologic warm-up and an initial orientation to the centrifuge and training procedures. This run is a relatively long, high-G exposure that requires considerable exertion for most aircrew. We consider the resulting fatigue to be particularly important, so that aircrew will be required to perform a more maximal AGSM to successfully complete the later runs. It probably more closely produces the physiologic condition of the aircrew that may exist during flight when a maximum AGSM might be critically important. The specific muscle fatigue also illustrates to aircrew what muscles are utilized to battle the adverse effects of $+G_z$ -stress and many times provides the impetus for aircrew to initiate (or at least recognize the importance of) a specific physical conditioning program to enhance $+G_z$ -duration tolerance. The gradual onset run which usually requires a considerable period at high $+G_z$, without an anti-G suit, and which allows considerable pooling of blood in the $+G_z$ -dependent areas prior to beginning an AGSM, is prone to inducing excessive parasympathetic tone (vagal reactions), especially in the post $+G_z$ -stress period. Some have therefore considered this an undesirable training profile (6,7). We, however, consider it an essential part of the centrifuge training program and have the concurrence of our aviators. Aviators understood similar logic for the long 30s moderate $+G_z$ -level practice run (training profile 2 at $+6G_z$). In fact, even though this is a severely fatiguing run, some trainees requested additional practice runs; comment number 34 from a 38 year old A-7 pilot: "Need another 5 or 6G profile to practice hook maneuver"; and comment number 129 from a 33 year old F-14 pilot: "Perhaps another practice run." We believe that additional practice runs would be very valuable, if more than a single centrifuge exposure were possible. At least a two-day program would solve many problems and greatly enhance our ability to work with the fighter crews. Many aviators concur with this opinion; comment number 10 from a 41 year old F-4 pilot: "2 tries in the bubble - debrief/critique the first/rest/review/try again"; comment number 17 from a 29 year old F-14A RIO: "Would like to see a 2-day program"; comment number 32 from a 26 year old F-14A RIO: "Make it 2 days with two sessions to see if there is any improvement"; comment number 86 from a 38 year old F-16N pilot: "Make this a 2-day program and add more on physical conditioning"; and comment number 7 from a 40 year old F-18 pilot: "Believe it or not - 2 shots at the training - first one in 5-6G range/second trip 7-8G's." Expansion of the G-training program is very dependent on the accessibility of the centrifuge for aircrew. If we have a centrifuge located near the aviators, expansion would be much easier. Cost, lost time away from primary duty, and logistics are difficult problems to overcome with the centrifuge not co-located with the aviators. We had initially thought many of the naval aviators who flew fighter-attack aircraft with maximum $+G_z$ capability considerably less than the levels of the training profiles might not understand the logic behind the $+8G_z$ and $+9G_z$ runs. Although there were some suggestions to reduce the maximum $+G_z$ -levels for the runs, the vast majority understood and agreed with the characteristics of the current profiles. If anything, the aircrew recommendations were for more exposures rather than modifying the existing runs or reducing the number of runs. The exception might be with respect to the last run (profile 5, the $+9G_z$ for 10s exposure in a "check-six" position). We consider this run a first transition to using the AGSM while doing something besides just looking straight ahead. It requires the aviator to be in a less than optimal position for performing an AGSM. Initially this particular run was instituted for these reasons and

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because it was thought that many of the inflight G-LOC episodes had occurred in this position and that overall tolerance may have been reduced in this position. There is no indication from centrifuge work that tolerance is markedly affected in this position. Our major recommendation for modification of a one-day program would therefore be to eliminate this run and add a closed-loop ACM profile with the aviator tracking a bogey aircraft.

A significant number of aircrew strongly recommended a run that would take them to G-LOC; comment number 31 from a 28 year old F-14A pilot: "I think it would be enhanced if the trainee was allowed to experience a complete loss of consciousness in order to be more prepared for the actual combat/training situations if it should happen. The experience would prepare us both physiologically and psychologically"; comment number 100 from a 26 year old F/A-18 pilot: "Don't get cocky on last run and let up. I definitely think I benefited more from this [G-LOC] than anything else! Recommend all TACAIR pilot's be brought to the point of loss of consciousness"; and comment number 1 from a 27 year old F-14 pilot: "Take everyone to G-LOC." We very strongly agree with the recommendation and believe it would have many benefits: (1) understanding of individual symptoms associated with G-LOC, (2) reduced incapacitation (enhanced recovery) should G-LOC occur inflight (8), (3) increased respect for the high-G environment and its inflight threat, and (4) enhanced recognition and reporting of inflight G-LOC episodes. The benefits of a G-LOC exposure (at least an optional one) are very great, the exposure is acceptable to aircrew, and it is well within acceptable safety limits. We have previously recommended "G-LOC training" and other air forces already employ G-LOC exposure as part of centrifuge training (8,9).

Additional recommendations very worthy of consideration include performing the training with flight gear: comment number 32 from a 26 year old RIO: "Do it in full flight gear"; and comment number 106 from a 25 year old F/A-18 pilot: "I would like to do it with a helmet on"; having a maximum tolerance exposure: comment number 134 from a 29 year old F-14 pilot: "Allow me to increase G to experience the point of max G-tolerance"; and comment number 133 from a 35 year old A-7E pilot: "Run where blackout induced then back off enough to regain situational awareness then reapply G"; and providing the ability for the trainee to review his performance after each run: comment number 79 from a 28 year old F/A-18 pilot: "I would like to review the previous run before the next run."

Many of the aviators had very strong opinions concerning exactly when the training should be given. This was in part because we openly solicited their opinion on this important point. Since this is a new training program it is necessary to train all actively flying fighter-attack aviators irrespective of where they currently are in their career. This makes a relatively heterogeneous group for training purposes. It was recommended and/or assumed by most aircrew that the training would eventually be given very early in a fighter-attack aviator's career, once all current veteran aviators receive their initial training; comment number 12 from a 30 year old F-16N/A-4 pilot: "Course should be incorporated in 'RP' orders, i.e., on the way to the R.A.G. [Replacement Air Group] and then some type of refresher syllabus"; and comment number 85 from a 23 year old A-4/F-16 pilot: "Great training especially for P.A.G students (wish I would have had it in the RAG)." Some aircrew thought a one time training session was all that was necessary; however, the majority considered multiple training sessions should be mandatory; comment number 87 from a 48 year old F-5 pilot: "Refresher at 3 yr. cycles"; comment number 99 from a 24 year old F-14 RIO: "Like physiology training this should be done periodically"; and comment number 122 from a 40 year old F-18 pilot: "Have us come back in 6 months to do it again. The learning curve is very rapid and would be even greater with the reinforcement a repeat visit would provide." The extreme importance of G-acclimation was once again voiced by aircrew in their training critiques. Although it is an accepted fact by veteran fighter-attack aviators, we still have almost no scientific information quantifying the kinetics of G-acclimation and de-acclimation. Acclimation to the high-G aerial combat environment is equivalent to training for other athletic endeavors and the adaptation required for exposure to high altitude. To maximize the benefits of high-G training, the trainees should be G-acclimated when they participate in the training; comment number 126 from a 24 year old F-14 pilot:

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"Would have been better if I had been flying recently. I was out of the cockpit for 3 months": comment number 127 from a 27 year old F/A-18 pilot: "Make sure people are up to speed before sending to training. I haven't flown in 2 months and nothing over 3G's for 4 months"; and comment number 137 from a 22 year old F-14 pilot: "Good training; however, should be given at different times during [flight] training - I haven't flown in 4 months. Should be given before tactics stage." We strongly concur with these recommendations and suggest that it be mandatory that only aircrew meeting specific currency criteria should be considered eligible for the training. They should also return to flying following training to allow maximum transition of the principles to the aerial combat flight environment. Not only would the training be improved with G-acclimation, it is much easier on the aviator, and therefore a safer endeavor. We also give the very strongest concurrence with the benefits of training individual squadrons all at one time; comment number 141 from a 29 year old A-7E pilot: "Suggest squadrons participate as a whole all at once." There are multiple benefits associated with training entire squadrons all at once, not the least of which is keeping the aircrew trainees much more at ease in the unfamiliar centrifuge training environment by being with their comrades. Generally, there is much more exchange and free flow of ideas between squadron mates and the training sessions are usually much more lively and if it is possible - more fun. We believe the learning curve is steeper when single squadrons undergo training as a class.

An important exclusion from the recommended changes in the training program was related to electrocardiographic (EKG) monitoring of aircrew during exposure to $+G_z$ -stress. At NADC all naval aviators are required to have EKG monitoring during the training. Not a single aviator mentioned anything about stopping the EKG monitoring. Many were very much in favor of the EKG monitoring as reflected in the review of other aspects of the aircrew critiques (2,3). It is evident that if handled appropriately, EKG monitoring of aircrew is not the least, but threatening, markedly enhances the training, ensures $+G_z$ -cardiovascular tolerance, and further enhances training safety (11).

CONCLUSIONS

Overall, we have summarized the recommendations from the aircrew responses concerning how we could change the centrifuge training program to better serve their operational needs. As evidenced from the analysis of other portions of the aircrew critiques, it was evident that aircrew were pleased with the current training program, and alterations to the existing program should be very carefully evaluated prior to implementation. The addition of a closed-loop ACM profile with a bogey on a tracking task should be vigorously pursued. The addition of at least an optional G-LOC exposure should also be implemented. The "G-LOC training" has a very good chance of saving lives and aircraft. These benefits are in addition to the current benefits resulting from isolated centrifuge training. Naval aviators are receptive to periodic refresher training. This should undergo further investigation to define if and when refresher training is beneficial and cost effective. A multitude of improvements to the training program can be made. These improvements are based on aircrew requesting such improvements to their training program so that their operational mission safety and combat effectiveness are improved. We have initiated an extremely successful program; however, it must remain a living program that responds to the needs of fighter-attack aircrews.

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REFERENCES

1. Gillingham KK, Fosdick JP. High-G training for fighter aircrew. *Aviat. Space Environ. Med.* 1988; 59:12-19.
2. Whinnery JE, Hamilton RJ. Aircrew critique of high-G centrifuge training: Part I. "What was the best part of the program?" Naval Air Development Center Technical Report, Report No. NADC-91054-60.
3. Whinnery JE, Hamilton RJ. Aircrew critique of high-G centrifuge training: Part II. "Comments on the G-awareness briefing." Naval Air Development Center Technical Report, Report No. NADC-91061-60.
4. Cammarota JP. Research in a high-fidelity acceleration environment. *Proceedings of the IEEE National Aerospace Electronics Conference*, pp 778-782; Dayton, Ohio, 1989 (Reprinted in *IEEE Aerospace and Electronics Systems Magazine*, 1989; 4:30-38).
5. Whinnery JE. On the theory of acceleration tolerance. Naval Air Development Center Technical Report, Report No. NADC-88088-60, 15 Feb 1988; Warminster, Pennsylvania 18974-5000.
6. Anderson H. Cardiac events during centrifuge training of aviators flying high performance aircraft. 38th International Congress of Aviation and Space Medicine; 10-13 Sept 1990; Paris, France.
7. Kappers A. Personal Communication Mar 1991.
8. Whinnery JE, Burton RR. +G_i-induced loss of consciousness: a case for training exposure to unconsciousness. *Aviat. Space Environ. Med.* 1987; 58:468-472.
9. Ponomarenko VA. Ninth Annual International Conference on Aviation Physiology and Training; AeroMedical Training Institute. Environmental Tectonics Corp., Southampton, Pennsylvania; Panel Discussion, 29 April - 3 May 1991.
10. Webb JT, Oakley CJ, Meeker LJ. Unpredictability of fighter pilot G-tolerance anthropometric and physiologic variables. *Aviat. Space Environ. Med.* 1991; 62:128-135.
11. Whinnery JE. The electrocardiographic response to high +G_i centrifuge training. *Aviat. Space Environ. Med.* 1990; 61:716-721.

TABLE 1. Summary of the aviator responses to the critique question "What can we change to better serve you?"

- I. NOTHING
- II. CLOSED-LOOP AERIAL COMBAT MANEUVERING PROFILE WITH BOGEY ON TRACKING TASK
- III. CENTRIFUGE GONDOLA CONFIGURATION MODIFICATIONS
 - 1. AIRCRAFT COCKPIT SIMULATION FIDELITY
 - 2. THROTTLES/STICK (AIRCRAFT SPECIFIC)
 - 3. RUDDER PEDALS
 - 4. ABORT SWITCHES
 - 5. ARM RESTS
 - 6. BACK SUPPORT
 - 7. SEAT CONFIGURATION
 - 8. WATER IN CENTRIFUGE
 - 9. AIR CONDITIONING IN CENTRIFUGE
 - 10. BLACKOUT CENTRIFUGE
 - 11. G-METER ON HUD DISPLAY (LARGE)
 - 12. BRIGHTER PERIPHERAL LIGHTS
 - 13. VISUAL/AUDITORY TIMING CUES
- IV. CENTRIFUGE TRAINING PROFILE MODIFICATIONS
 - 1. HIGHER G-LEVELS
 - 2. LOWER G-LEVELS
 - 3. ADDITIONAL PRACTICE RUN
 - 4. WARM-UP BEFORE 1st PROFILE
 - 5. MAXIMUM TOLERANCE RUN
 - 6. NO WARNING RAPID ONSET RUN
 - 7. BLACKOUT RUN
 - 8. G-LOC RUN
 - 9. "CHECK-SIX" PROFILE MODIFICATION
 - 10. REVIEW PREVIOUS PROFILE BEFORE NEXT PROFILE
 - 11. FLIGHT GEAR ADDED
- V. TIMING OF THE TRAINING MODIFICATIONS
 - 1. CHANGE TO EARLIER IN CAREER
 - 2. SQUADRON AS A GROUP
 - 3. RECURRENCE
 - 4. PREPARATION FOR TRAINING (ACCLIMATION)
 - 5. EXPAND TRAINING (2 DAYS)
 - 6. ONE TIME TRAINING
 - 7. REDUCE DELAYS
 - 8. EXPAND SCOPE

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APPENDIX I: G-TIP CRITIQUE

YOUR INPUT IS EXTREMELY IMPORTANT TO HELP IMPROVE G-TIP. YOUR COMMENTS WILL HELP THE NEXT GROUP OF AVIATORS AND WILL SERVE TO SHAPE THE FINAL G-TIP PROGRAM WHEN A DEDICATED TRAINING FACILITY IS COMPLETED. FAVORABLE COMMENTS ARE AS IMPORTANT AND HELPFUL AS CRITICISMS - PLEASE HELP US TO IMPROVE OUR PROGRAM FOR YOU! THANK YOU!!!!

1. COMMENTS ON TRAVEL, QUARTERS, AND TRANSPORTATION:
2. COMMENTS OF "G" AWARENESS BRIEFING:
3. COMMENTS ON CENTRIFUGE TRAINING:
4. COMMENTS ON FACILITIES:
5. COMMENTS ON PERSONNEL:
6. WHAT WAS THE BEST PART OF THE G-TIP PROGRAM (IF ANY)?
7. WHAT CAN WE CHANGE TO BETTER SERVE YOU?
8. GENERAL COMMENTS:

IN ORDER TO COMPARE YOUR NEEDED COMMENTS WITH OTHER AVIATORS, WE ASK THAT YOU FILL OUT THE FOLLOWING AND ADD ANY FURTHER COMMENTS THAT YOU FEEL ARE IMPORTANT TO THIS PROGRAM.

AGE: AVIATION STATUS:(PILOT, RIO, NFO) CURRENT A/C:

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DISPLAY QUALITY

DID THE DISPLAY EXHIBIT ANY CHARACTERISTICS DETRIMENTAL TO THE TRAINING? (I.E., FLICKER, NOISE, INADEQUATE RESOLUTION, SMALL FIELD OF VIEW)

THE DISPLAY IN THIS TRAINING WAS A REAL IMAGE LOCATED ON A CRT SCREEN. IT DOES NOT PROVIDE THE DEPTH PERCEPTION CUES OF A VIRTUAL IMAGE DISPLAY SYSTEM USED ON MOST FLIGHT TRAINERS. WOULD A VIRTUAL IMAGE DISPLAY SYSTEM ADD TO THE EFFECTIVENESS OF THIS TRAINING? (PLEASE RESPOND BY COMPARING A PARTICULAR FLIGHT TRAINER WHERE POSSIBLE.)

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APPENDIX II. AIRCREW RESPONSES TO CRITIQUE QUESTION:
"WHAT CAN WE CHANGE TO BETTER SERVE YOU?"

<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
1.	27		F-14	Take everyone to G-LOC.
2.	35		F-4	Build one in California.
3.	44		F-16	Need pad on back of seat.
4.	29		F-14	It if works don't fix it.
5.	30		F-4	Don't let anyone eat at Burger King just before run.
6.	26		F-4	Great program; don't change it.
7.	40		F-18	Believe it or not - 2 shots at the training - first one in 5-6G range/second trip 7-8G's.
8.	35		F-15	Belly dancers as coaches also more women and beer.
9.	29		F-16	Absolutely nothing.
10.			F-4	2 tries in the bubble - debrief/critique the first/rest/review/try again.
11.	31		F-15	Water in gondola.
12.	30		F-16N/A-4	Course should be incorporated in "RP" orders, i.e., on the way to the R.A.G. and then some type of refresher syllabus.
13.	26	NFO	F-14	Relocate to El Toro, California.
14.	25		F/A-18	Outstanding! Trigger switch on stick not real good. Could be replaced by pickle switch.
15.	25		F/A-18	Good training. Would like more info on exercises, diet and extraneous factors.
16.	29	RIO	F-14A	Would have liked to go to G-LOC! - to see what my symptoms are.
17.	29	RIO	F-14A	Would like to see a 2-day program.
18.	29		A-4/F-16	Integrate some type of bogey on a run.
19.	27		F-14	Environment of centrifuge more like cockpit.
20.	27		F-14	Worthwhile - do not believe I would benefit significantly by doing it again.
21.	32		A-4/F-16	Maybe some more padding on the seat in the lower back region.
22.	27		F-14	Seat does not give adequate lower back support - pressing with legs jams lower back into seat.
23.	34		F-14/F-16/A-4	Pickle switch was hard to hold down with sweaty palm - might want to use a trigger switch.

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<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
24.	34		F-14/F-16/ A-4	Would like one run that I could control all aspects of the run.
25.	39		F-16/A-4	More women.
26.	47		F-14/F-18	Need to get program to the West Coast. Need more coverage to all naval Aviators.
27.	26		F/A-18	Control stick and bogey.
28.	27		F/A-18	For check 6 run have 2 lights, one above the subject and one to the side. After initial onset, the subject should look up for a more realistic training run.
29.	36		F-16	Wouldn't change a thing.
30.	35		F-16	I don't believe F-16 drivers will be fighting lying back at 30° in any regime. You might include a more prone position.
31.	28		F-14A	I think it would be enhanced if the trainee was allowed to experience a complete loss of consciousness in order to be more prepared for the actual combat/training situations if it should happen. The experience would prepare us both physiologically and psychologically.
32.	26	RIO	F-14A	Make it 2 days with two sessions to see if there is improvement. Cockpit emphasis rather than ball environment.
33.	30		F-16N/A-7	Do it in full flight gear.
34.	38		A-7	Nothing.
35.	39		A-7	Need another 5 or 6° profile to practice hook maneuver.
36.	37		A-7	Make rudder pedals adjustable.
37.	38		A-10	Need more air conditioning in the capsule.
38.	34		F-15	Get hookers.
39.	30		F-15	Feet didn't reach rudder pedals to apply max push.
40.	30		F-15	Center stick.
41.	48		A-10	ACM profile - pilot controlled.
42.	37		A-10	Adjustable rudder pedals.
43.	27		A-6	Brighter/bigger peripheral lights.
44.	34		TA-4/F-14	Add G-meter in the ball.
45.	26		F/A-18	Bigger lights in periphery.
46.	28	Aerospace Physiologist		Have water to drink inside ball.
				Access to drinking water in capsule.

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<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
47.	39		F-4E	I would have killed for a squirt of water.
48.	34		F-15	Make rudder pedals adjustable.
49.	34		F-15	Throttle for left hand.
50.	42		F-15	An anesthetic.
51.	29		F-14A+	Tail chase video.
52.	29		F/A-18	Tin ing lights in the ball.
53.	25		F/A-18	Timer and G-meter inside ball.
54.	37		A-6	G-meter on the HUD and pilot controlled aerial combat maneuvering profile.
55.	38		F-16	Training was good enough that increased display capability might not add significantly.
56.	46		F-4E	Yes, any visual additions to simulate aircraft inside the ball will be more realistic.
57.	26		F/A-18	Much better with video in centrifuge, improved video could get 'heart pumpin' and 'fangs out'.
58.	31		A-6	HUD tracking would be nice although for non HUD aviators it may be more of a distraction. Emphasis should be on G-awareness/ anti-G straining maneuver.
59.	32		F/A-18	Nothing.
60.	37		F-16	Later on add an air combat profile.
61.	33		A-7E	It it ain't broke don't monkey with it - keep as is.
62.	43		F-4E	Encourage aircrews to fly and pull some G's prior to centrifuge training.
63.	27		AV-8B	Require pilot to perform more tasks while under heavy G to experience degradation of mental and motor skills.
64.	27		A-7E	More realistic cockpit layout.
65.	26		F-18	Fly up in am, GTIP all day, sleep overnight, PTB next am.
66.	42		F/A-18	Get the word out to the rest of the TACAIP community.
67.	25		F/A-18	Good ACM visuals.
68.	26		F/A-18	Stick and layout like in cockpit.
69.	29		F/A-18	Water in centrifuge.
70.	28		A-7	Recommend to future aircrew to get plenty of sleep, eat dinner and breakfast and do not drink night

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COMMENT NUMBER	AGE (YRS)	AVIATOR STATUS	AIRCRAFT	COMMENTS
71.	25		A-7E	before training like I did!
72.	39		F/A-18	Could not have been a smoother training process.
73.	27		A-7E	Don't fix it if it works. It's good now.
74.	24		F-14	Excellent as is.
75.	28		F-14	Use F-14 cockpit and run with a tail chase.
76.	25		F-14	Simulated aerial combat run.
77.	31		F-14	More visuals in ball; more pilot control of G-onset.
78.	25		F-14A	The program is excellent. There aren't any 9G jets in the Navy. Might change training to include longer 6.5 to 7.0G rides versus 9.0G.
79.	28		F/A-18	I do not feel that improvements to cockpit are necessary for 2 reasons: 1. Making the trainer a "dog fight G trainer" when you would look all around the cockpit to track a bogie would be great if the opportunity to use it on a routine basis existed. It doesn't however; 2. When pulling 6+ G's engaged with a bogie you will not be looking at consoles, pushing buttons, etc.
80.	30		A-4/F-16	I would like to review the previous run before the next run. Now that I'm done - up the G levels.
81.	39		A-7	Add an ACM profile.
82.	38		A-7E	A simulated ACM engagement with variable G environment.
83.	29		A-7E	ACM.
84.	40		A-7E	Make arrangements to train all A-7, F-14, F-18, F-16 aircrew ASAP!
85.	28		A-4/F-16	Make red lights brighter. Great training especially for RAG students (wish I would have had it in the RAG).
86.	38		F-16N	Make this a 2-day program and add more on physical conditioning.
87.	48		F-5	Refresher at 3 yr. cycles.
88.	39		F-15	Water in centrifuge.
89.	24	RIO	F-14	One run where you pass out just to let you know all about it.

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<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
90.	36		F-18	Cool the centrifuge - too hot. Take all the way to G-LOC to see the start of it and the after effects.
91.	36		F-18	I think everyone if they had not experienced G-LOC before should do so in the centrifuge just once.
92.	26		F/A-18	I went through a couple of gallons of adrenalin waiting around 4 hrs. to actually ride the centrifuge.
93.	35		F-18	G-profile that would match a fight.
94.	35		F-16	Schedule AM and PM classes with sound on slide learning carousels for the briefing - too much time waiting for your turn.
95.	30	Aerospace Physiologist		Cockpit realism. Use full equipment.
96.	37		F/A-18	One-on-one coaching.
97.	33		F/A-18	Complete pilot controlled acceleration.
98.	29		AV-8B	Perhaps some type of concentration tasks (monitor altitude, airspeed, track simulated bogey).
99.	24	RIO	F-14	Like physiology training this should be done periodically.
100.	26		F/A-18	Don't get cocky on last run and let up. I definitely think I benefited more from this than anything else! Recommend <u>all</u> TACAIR pilots be brought to the point of loss of consciousness.
101.	29		F-14	Can't be improved.
102.	28		F-14	If possible configure stick to where it would be in your particular aircraft.
103.	36		F-14A+	Would like stick in the middle.
104.	27		F/A-18	I can see an addition of more tactical cockpit tasking during G. It would be interesting to see what level of cockpit task saturation would begin to erode G-tolerance...targeting, problems, missile breaks, etc.
105.	27		F/A-18	Throttles and stick to simulate F-18 better.
106.	25		F/A-18	I would like to do it with a helmet on.
107.	25		F-14	Cockpit configuration - arm rests

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<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
108.	28		A-7E	Get rid of the second (black)
109.	27		A-7E	<u>Every</u> tactical aviator needs to experience it. 2-1/2 days and nights is too long to complete the entire program.
110.	30		F-4E	Take us up to unconsciousness level.
111.	39		F-16	Tough to improve on a good program.
112.	40		F-4E	Cold beer after the ride.
113.	24		F-14A+	A program to allow the pilot to fly out experience G-LOC and then fly home would be excellent and should be aggressively pursued.
114.	26		F/A-18	A water bottle in the ball.
115.	26		F/A-18	Good training, emphasis on G-LOC (symptoms and onset) would be better than max G's one can stand.
116.	26		F-18	Blackening inside ball might better simulate cockpit.
117.	27		F-14	Try to simulate dog fights.
118.	27		F-14	Set throttle friction to correspond with aircraft.
119.	33		F-14	I question the validity of the 9G check 6 run.
120.	29		AV-8B	Put a bogey on screen to analyze performance during G and G-LOC.
121.	28		F-16/A-4/F-18	Air conditioning in ball.
122.	40		F-18	Have us come back in 6 months to do it again. The learning curve is very rapid and would be even greater with the reinforcement a repeat visit would provide. Recommend this for all aircrew!
123.	41		F/A-18	Put G meter on HUD. A little too much delay in G-onset after stick pulled - timing of first hook is difficult.
124.	29		A-4/F-16	Let pilot sit head-up if they like, vice in head rest. Maybe a 4G x 30 sec then 6G x 20 sec before 8 and 9G runs for 10 sec. Super personnel and program.
125.	30		F-14	Don't let students observe while fellow students training - seems to promote more competition than learning. By the time it's their turn in the ball they know what to do.
126.	24		F-14	Would have been better if I had been flying recently. I was out of cockpit for 3 months.

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<u>COMMENT NUMBER</u>	<u>AGE (YRS)</u>	<u>AVIATOR STATUS</u>	<u>AIRCRAFT</u>	<u>COMMENTS</u>
127.	27		F/A-18	Make sure people are up to speed before sending to training. I haven't flown in 2 months and nothing over 3G's for 4 months.
128.	27		F-14	More cockpit simulation in ball.
129.	33		F-14	Perhaps another practice run.
130.	28		F-14	Make one run pilot controlled with pilot pull until grey then work the stick to keep sight - would give better idea of "working" limit.
131.	32		F-14	Maybe some visual or aural timing cues for the G-straining maneuver.
132.	32		F-14	Maybe a warm-up before 1st run to practice G-strain and get body ready.
133.	29		F-14	Put some foam on arm rest.
134.	29		F-14	Allow me to increase G to experience the point of max G-tolerance.
135.	33	NFO	F-14	Add a left arm rest in G chamber.
136.	24	NFO	F-14	Give an additional run with no warning of the onset to show how to get back on top.
137.	22		F-14	Good training; however, should be given at different time during training - I haven't flown in 4 months. Should be given before tactics stage.
138.	35		A-7E	Run where blackout induced then back off enough to regain situational awareness then reapply G.
139.	27	RIO	F-14	Centrifuge was a might toasty.
140.	25		F-14	Run chasing a bogey on a screen - so that you focus on trying to hose his brains out while trying to hook.
141.	29		A-7E	Suggest squadrons participate as a whole all at once.

Note (1): These responses are all the responses other than the isolated expletives such as "tremendous, superb, great, etc." No screening of the comments otherwise has been accomplished.

Note (2): When "AVIATOR STATUS" is not listed it was from a pilot.

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