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Quantifying Human Performance on a Moving Platform Using the Fitts' Law Task

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- Purpose of the Fitts' Law Task
- NPS Experience with Sleep and Motion Studies
- Isoperformance Examples
- Approach to calculating norms for the Task
- Fitts' Law Task Demonstration



LCS Sea Trials this winter and spring

- PMS 501 (sponsor)
- PMS 420 (sponsor)
- Office of Naval Research (sponsor)
- Naval Surface Warfare Center Panama City Division
- Naval Surface Warfare Center Dahlgren Division
- Naval Postgraduate School
- Johns Hopkins University Applied Physics Laboratory



- Speculation that Motion-Induced Interruptions (MIIs) also cause performance decrement
- Self-reports from Sailors indicate that severe motion interferes with performance, especially in fine motor tasks
- Challenge is how to quantify the level of degradation so that comparisons can be made among systems



NPS Sleep Studies in Naval Operations

Naval Vessel	Mission (Length of Study)	Participants	Method of collecting sleep data	Gender	Average Daily Sleep In Hours (\pm s.d.)
USS PROVIDENCE and other SSN or SSBN Blasingame (2001)	NA (N/A)	167 submariners	Survey	NA	Selfreport ~6 (while at sea) (-)
USS PROVIDENCE, USS CONNECTICUT, and other SSN or SSBN Gamboa (2002)	NA (N/A)	258 submariners	NA	NA	NA (-)
USS STENNIS (CVN) Nguyen (2002)	Operation Enduring Freedom NAO (3 days)	33 enlisted sailors	Actigraphy and sleep logs (n=28)	22 males 6 females	6.28 (-)
USS STENNIS (CVN) Sawyer (2004)	Operation Enduring Freedom (7 days)	24 crewmembers	Profile of Mood States (POMS) administration	19 males 5 females	NA (-)
USS HENRY M. JACKSON Osborn (2004)	At sea trials (32 days)	41 submariners	Actigraphy and sleep logs (n=29)	males	6.67 (\pm 2.56)
HSV-2 SWIFT McCauley, Matsangas & Miller (2004)	Transiting and conducting sea-keeping trials (13 days)	19 total; 1 officer 16 enlisted 2 civilians	Sleep logs (mainly) and actigraphy	18 males 1 female	7.5 (\pm 2.13)
HSV-2 SWIFT Archibald (2005)	GOMEX 05-1 MIW (8 days)	21 total; 3 officers 18 enlisted	Actigraphy and sleep logs (n=21)	19 males 2 females	6.78 (\pm 1.5)



NPS Sleep Studies in Naval Operations

USS CHUNG HOON (DDG) Haynes (2007)	Pre-deployment training (14 days)	25 total; 2 officers 23 enlisted	Actigraphy (n=22) and sleep logs (n=25)	NA	7.27 (\pm 1.03)
USS LAKE ERIE and USS PORT ROYAL (CG) (Mason, 2008) and (Unpublished data)	RIMPAC exercise 2008 (24 days)	70	Actigraphy and sleep logs (n=70)	NA	5.58 (\pm 1.92)
USS RENTZ (Green, 2009)	Pre-deployment workups (24 days)	24 total, 3 officers 21 enlisted	Actigraphy and sleep logs (n=24)	males	6.71 (–)
Sleep on Motion-Based Platform (Grow & Sullivan (2009)	Laboratory experiment (2 nights of sleep)	12 NPS graduate students	Actigraphy and sleep logs (n=12)	11 males 1 female	NA (–)



NPS Sleep Studies in Combat Operations

Unit or Context	Mission/(Length of Study)	Participants	Method of collecting sleep data	Gender	Average Daily Sleep In Hours (+s.d.)
Warfighters at Iraq and Kuwait Doheney (2004)	Operation Iraqi Freedom (OIF) - Phase IV (--)	273 total: 244 enlisted 22 officers	surveys	237 males 24 females	Self report 6.67 (--)
USMC Rotary Wing Aviation Battalion in Iraq (Unpublished, 2006)	Rotary wing flight operations in Iraq (10 days)	20 pilots	actigraphy and sleep logs (n=20)	N/A	6.5 (+1.66)
Naval Aviation MH-53 (Rotary Wing) squadron, Solberg (2006)	Mine Hunting Operations (14 days)	25 aircrew	actigraphy and sleep logs (n=25)	20 males 2 females	7.47 (+1.65)
Fort Benning Survey Miller et al (2010)	Infantry Officers returning from Iraq/ Afghanistan (--)	46 infantry officers	surveys	males	Self report by OPTEMPO: Low: 7.8 (--) Moderate: 6.0 (--) High: 3.9 (--)



NPS Sleep Studies in Training and Educational Environments

Unit or Program	Mission/(Length of Study)	Participants	Method of collecting sleep data	Gender	Average Daily Sleep In Hours (+s.d.)
USN Enlisted training at RTC, Great Lakes Baldus (2002)	Enlisted training (~63 days)	31 USN recruits	Actigraphy and sleep logs (n=31)	20 males 11 females	6.1(+1.2)
USN Enlisted training at RTC, Great Lakes Andrews (2004)	Academic performance (3 years of test scores)	2597 USN recruits	Test scores retrospective analysis No sleep data	NA	NA (--)
United States Military Academy, West Point, 4-Year Longitudinal Study of Sleep in Cadets (Kenney/ Neverosky, 2003); Miller, 2005; Godfrey, 2006; DeVany, 2008; Miller & Shattuck (2005, 2010)	Military undergraduate university (4 years of data, 2 months per year)	~1400 (80 cadets selected for actigraphic recording)	Actigraphy and sleep logs (n=80) Surveys (n~1400)	56 males 24 females	5.60 (+1.49)



NPS Sleep Studies in Training and Educational Environments

USN Officer Candidate School, Newport, RI, O'Connor, Patillo (2003)	Officer training and indoctrination (6 days)	20 faculty and students	Actigraphy and sleep logs (n=20)	NA	NA (--)
MAWTS-1 Maynard (2008)	Flight training WTI 2-05 (43 days)	13 total, students (n=6) instructors (n=7)	Actigraphy and sleep logs (n=13)	NA	Students: 5.62 Instructors: 6.10
	Flight training school WTI 1-06 (44 days)	20 students	Actigraphy and sleep logs (n=20)	males	7.05 (+0.74)
Fort Leonard Wood Miller et al (2010)	Basic combat training (63 days per unit)	394 recruits and cadre	Actigraphy and sleep logs (n=94 recruits)	59 males 35 females	Intervention: 5.89 (+1.21) Control: 5.33 (+1.18)



Obtaining adequate sleep is a challenge in the military environment...

- Sleep deprivation is prevalent in military training & education programs (Andrews, 2004; Baldus, 2002; Killgore et al., 2008; Miller, 2005; Miller et al., 2010)
- Military recruits are adolescents / young adults with sleep-wake patterns that often conflict with contemporary organizational schedules
 - Delayed bedtimes, later awakenings & longer sleep periods
 - May require 8.5–9.25 hrs sleep per night for optimal performance (Carskadon et al., 1997, 1998; Wolfson & Carskadon, 2003)
- Motivation only partially compensates for effects of sleep deprivation (Pigeau, Angun, O'Neil, 1995)



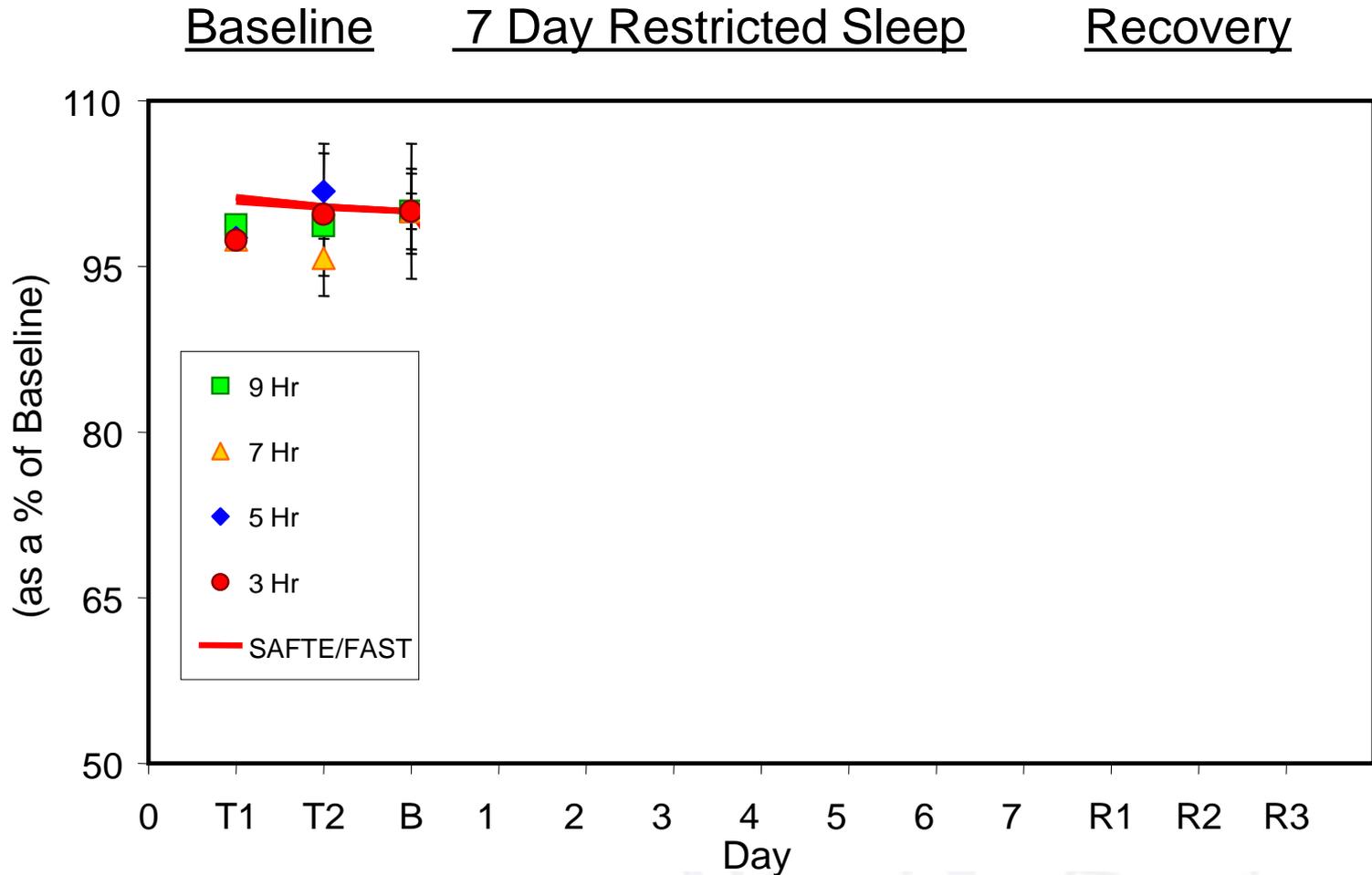
Widely accepted findings that fatigue interferes with performance:

- Attention and vigilance
- Memory consolidation and recall
- Creativity
- Decision-making under uncertainty (especially with increasing age)
- Moral judgment
- Health consequences



WRAIR Restricted Sleep Study: PVT Adaptation to Chronic Sleep Restriction

Mean Speed on Psychomotor Vigilance Task
(as a % of Baseline)



(Belenky et al., 2003)



Insufficient sleep has known negative effects on training & education...

- Multiple nights of less than 8 hours sleep result in sleep debt & fatigue, the consequences of which include:
 - Decreased vigilance, adverse mood changes, perceptual & cognitive decrements (Krueger, 1990; Belenky et al., 2003; van Dongen et al., 2003)
 - Impaired judgment & increased risk taking (Killgore, Balkin, & Wesensten, 2006)
 - Decreased marksmanship (Tharion, Shunkitt-Hale, & Lieberman, 2003; McLellan et al., 2005)
- Ability of individuals to learn & retain information is impaired by sleep deprivation
 - Role of sleep in memory consolidation and latent learning (Fenn et al., 2003; Gais et al., 2000; Stickgold et al., 2000; Walker et al., 2003)
 - Learning curves drop for adolescents with 4–6 vs. 8 hrs sleep (Graham, 2000)
 - Positive correlation between academic performance & daily sleep (Trickel et al., 2000; Killgore et al., 2008)

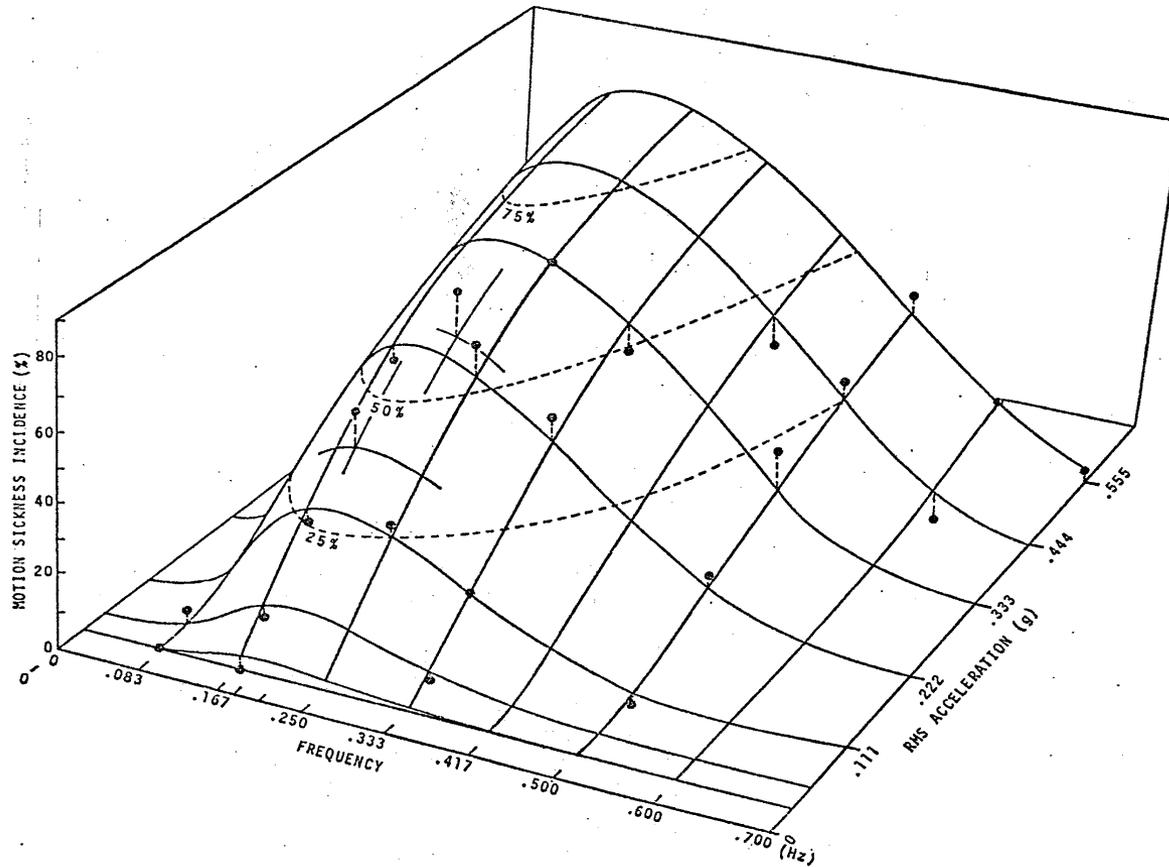


Figure 8. Three-dimensional representation of the current model of Motion Sickness Incidence as a function of wave frequency and acceleration for 2-hour exposures to vertical sinusoidal motion.



- Participants will be asked to take the Fitts Law Task periodically throughout the course of the day, particularly when events occur that are likely to produce motion-induced interruptions (MIIs). The task will capture reaction time, traverse time and error (RMS deviation from straight line), speed and accuracy. The task will be performed using a tablet PC. In the first screen, shown below, participants will enter their assigned participant code.



Enter Name on Screen 1





- Then, a set of instructions will appear that describe the task to be accomplished—including the scoring algorithm. The participant will be instructed to 'Press Start' to begin the task (see Figure 2).



Instructions on Screen 2

SCORE  BALLS 

[Scores](#) [Quit](#)

Press and hold the box at the bottom of the screen to release a ball. Drag the ball into the basket. A circle will be drawn on the graph based on how quickly you put the ball into the basket. The predicted Fitts value will also be shown as a crosshair. If you miss the basket, no point will be drawn.

Final score will be

- + 50 Points for making a basket
- 100 Points for missing
- + 600ms - Average Response Latency
- + 300 - Average Course Deviation

The response latency is the time it takes from when the ball appears till you touch the ball.

The course deviation is the distance you move from the red line while moving the ball.

[Click to start](#)





- Then a screen will appear that resembles a basketball and half a basketball court with a basket at the right side of the screen. Participants will be asked to press and hold the gray box at the bottom of the screen (see Figure 3.)



Fitts' Law Task, Screen 3

SCORE 0000 BALLS 30 Scores Quit

Time

Distance/Width

PRESS AND HOLD HERE



- Then, a series of 30 trials will be offered to each participant in which they will be asked to drag the basketball to the hoop as quickly and accurately as possible. Scores will be saved for each attempt, associated with the participant code and the time of administration.



Fitts' Law Task, Screen 4

SCORE 0000 BALLS 30 Scores Quit

Time

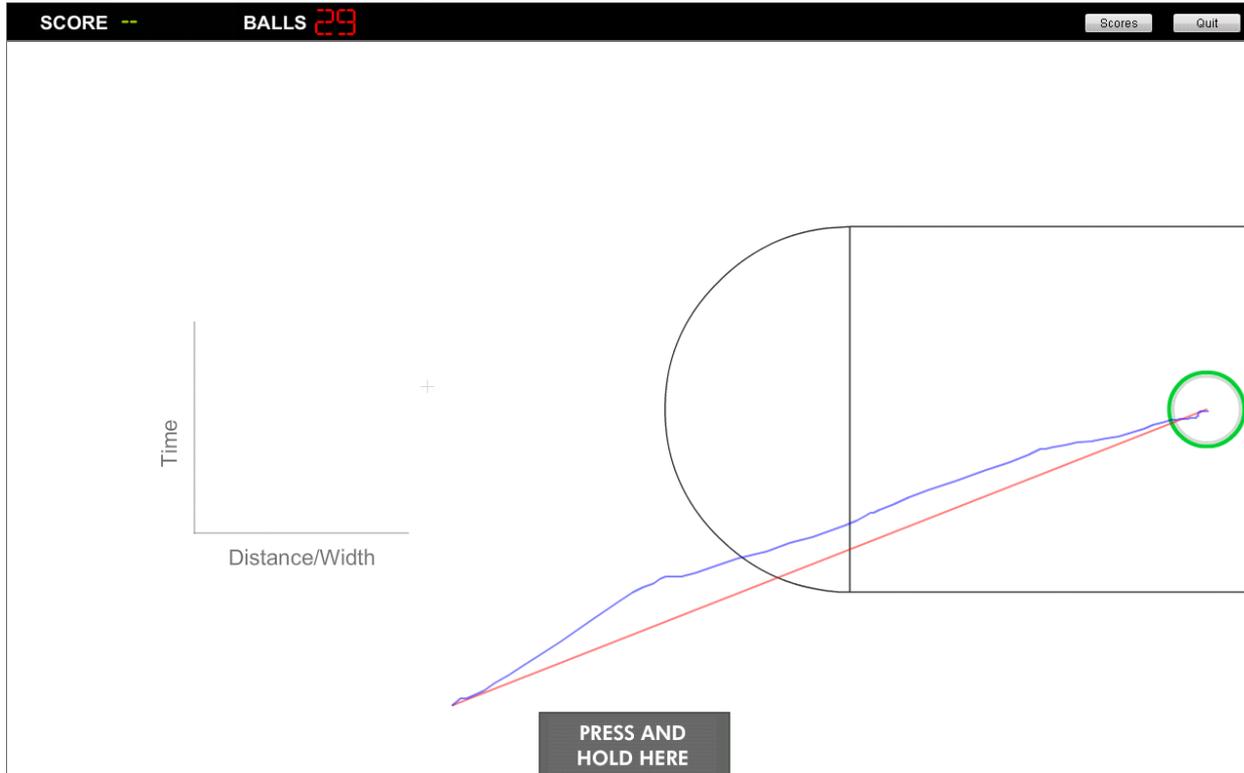
Distance/Width



- The following screen captures illustrate the data that are collected in the Fitts Law Task. The task will take approximately 2 minutes per administration, with longer times required for individuals who are slower.



Fitts' Law Task, Screen 5

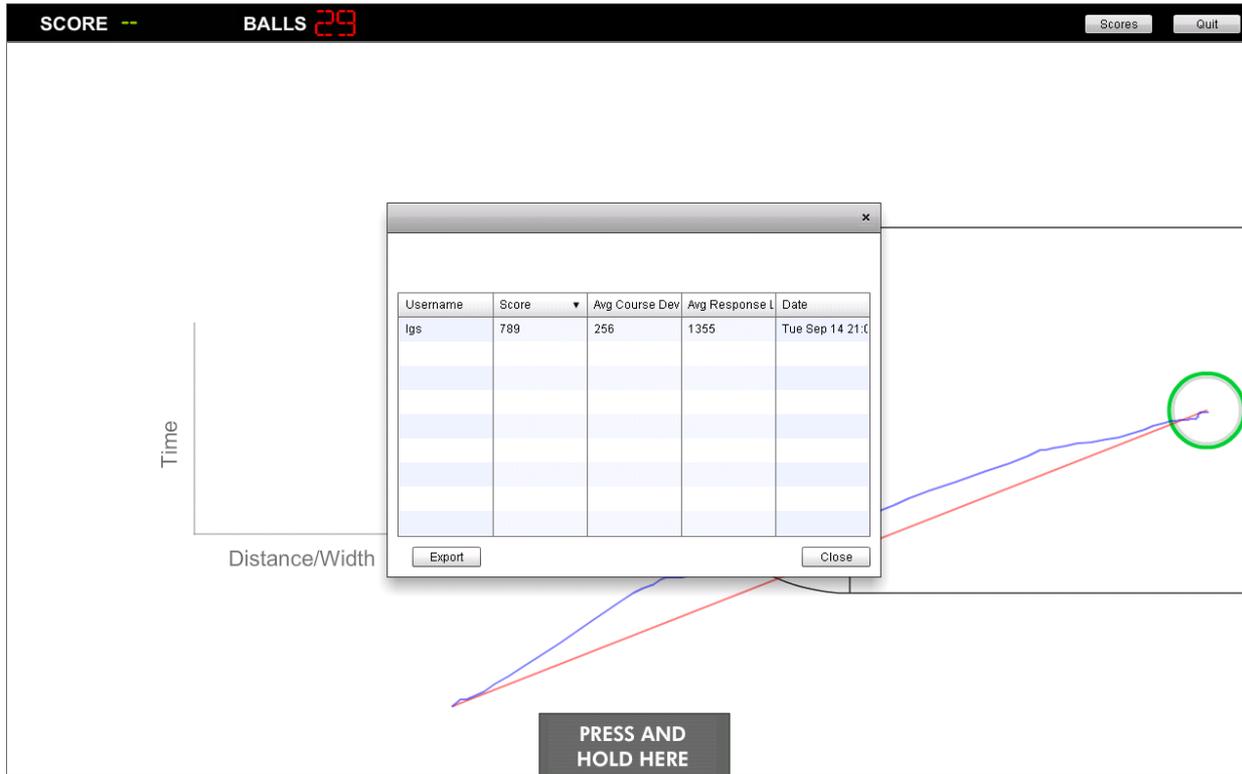




- Scores are calculated and the results displayed to the participant.



Fitts' Law Task, Screen 6





Multiple Phases

- In laboratory (stationary conditions)
 - Training effects? Time to achieve asymptotic performance? (NPS Student project)
 - Performance in known motion conditions (motion-based platform)
- In Field studies
 - In terrestrial vehicle (golf carts around Del Monte Lake)
 - On-board LCS and other surface combatants