ON THE USE OF MOBILE APPS FOR IMPROVED MARITIME SAFETY

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ABSTRACT

In the summer of 2011, a simple, efficient, and low development cost Small Craft Motion Program (SCraMP) was released for iOS devices, with successive updates and enhancements in the time since. The purpose of this effort was to empower low budget operators with critical information pertaining to the state of their vessel. Capitalizing upon internal device hardware that would have cost thousands of dollars only a few years ago, the iOS application provides acceleration and rotation data, an index measure of severity of motions, statistics related to motions, and location information in a simple and interactive graphical user interface. This paper will discuss the use of smartphone applications like SCraMP as occupational safety intervention tools specific to maritime operations. Included in the paper will be an overview of SCraMP along with user feedback as to how such an app can inform operational decisions for safety. The author will also discuss a second maritime safety app recently developed and released in partnership with the Alaska Marine Safety and Education Association (AMSEA) entitled FVdrills which delivers previously published drill checklists (Jensen and Dzugan, 2009) into a smartphone app format. Therefore, the focus of the paper will be upon improving maritime safety via comparably low-cost, portable, smartphones to deliver data to operators and the ensuing user feedback.

Keywords: capsize; drills; portable maritime safety intervention.

RESUMEN

En el verano de 2011, un software sencillo, eficiente y de bajo coste de desarrollo, “Small Craft Motion Program” (SCraMP), fue puesto en el mercado para equipos iOS, con sucesivas actualizaciones y mejoras desde entonces. El propósito de este esfuerzo era brindar a operadores de bajos recursos información crítica referente al estado de su embarcación. Aprovechando el hardware de equipos internos que de otro modo hubieran costado miles de dólares hace algunos años, la aplicación iOS brinda datos de aceleración y rotación, un índice de medida de la severidad de los movimientos, estadísticas respecto a los movimientos, e información de la posición en una interfaz gráfica con el usuario sencilla e interactiva. Este artículo discutirá el uso de aplicaciones como SCraMP para smartphones, como herramientas de intervención de la seguridad ocupacional específica para operaciones marítimas. En el artículo se incluirá una visión general de SCraMP junto con comentarios de usuarios sobre como una aplicación de este tipo puede dar información para tomar decisiones operacionales para la seguridad. La autora también discutirá una segunda aplicación sobre seguridad marítima recientemente desarrollada y lanzada al mercado, en conjunto con la Alaska Marine Safety and Education Association (AMSEA), llamada FVdrills que provee listas de control de ensayos previamente publicadas (Jensen y Dzugan, 2009) en un formato de aplicación para Smartphone. Por lo tanto, el enfoque del artículo será al mejoramiento de la seguridad marítima a través de smartphones relativamente económicos y portátiles que brinden datos a los operadores, y los consiguientes comentarios de los usuarios.

Palabras clave: zozobre; ensayos; intervenciones portátiles de seguridad marítima
INTRODUCTION

From ferries to fishermen, maritime accidents exact tremendous costs in lives and cargo every year. When fiscal considerations enter the discussion, mariners can be hard pressed to choose between life saving tools and profit increasing tools. Therefore, the author has embarked on recent efforts to develop low cost, smartphone based, occupational safety interventions for maritime workers. This paper describes two such “apps,” one entitled the Small Craft Motion Program (SCraMP) and one entitled FVdrills. Both are available to free via Apple’s iOS app store for individuals who have iOS devices such as the iPod touch, iPad, or iPhone. In addition to describing the apps, results of an initial assessment effort of SCraMP are provided.

SCRaMP—DESCRIPTION

SCraMP was developed initially to provide low budget commercial fishing operators access to critical information regarding their vessel's stability and safety. The author was pleased to find interest in the maritime industry outside commercial fishing, including amongst ferry operators. Specifically, SCraMP makes use of internal device hardware to provide users real-time displays of acceleration, rotation, and location, along with user customizable motion severity metrics, audible alarms, and the ability to record data. Sample screen captures for SCraMP are presented in Figure 1.

![Sample screen captures for SCraMP](image1.jpg)

At present, three safety metrics are incorporated into SCraMP: index, GM, and period. The index metric contained in SCraMP is given in Equation (1), where $\phi$ is roll, $\theta$ is pitch, and $z$ is heave. Overdots denote derivatives with respect to time. This index was inspired by work from the realm of sea-based aviation by authors such as O’Reilly (1987), Ferrier et al (1998, 2000), and Sherman et al (2007).

$$\text{index} = \dot{\phi} \dot{\theta} + \dot{\theta} \dot{z}$$

The development of SCraMP has been supported in part by the Office of Naval Research and the National Science Foundation. Portions of this app have been adapted from Apple's AccelerometerGraph demo, Nicholas Vazirani, CoreLocation GPS tutorial, Jeffrey Power, “CoreMotion and the Gyroscope” slides, and other code snippets from altibrights like “Coco Is My Girlfriend!,” “Tap to Go Back,” “WheelOfFortune,” “iPhone Desk SOC,” and the rest of the wonderful community of iOS developers. The index metric is loosely based upon ET research by O’Reilly (1987) and BSI research by Sherman et al. (2007). For further information on SCraMP and/or to suggest improvements for future versions, please visit [http://www.gstechcrania.com](http://www.gstechcrania.com).
The graphical display of the index is set to be green from 0-2, yellow from 2-4, and red from 4-6. If any one parameter reaches its limit value, red is displayed. Because small craft operators are the target audience, roll and pitch displacements along with heave accelerations were identified as critical parameters for the index metric. Note the operator is able to tailor the metric to their needs and craft by entering their desired roll, pitch, and heave limits.

The GM estimate is calculated per Equation 2, which appears in numerous references, such as Goldberg (1988) and the IMO’s Maritime Safety Committee (2010). In Equation 2, $B$ denotes the beam of the craft in feet, $T$ is the roll period in seconds, and $C$ is an empirical constant; taken for purposes of this application to be $0.44\, \text{s/√f’t}$ (which corresponds to approximately $0.8\, \text{s/√m}$, typical of that reported in references using metric units). The user must enter the craft’s beam for the GM metric.

$$GM = \left(\frac{CB}{T}\right)^2$$  \hspace{1cm} (2)

As noted in Principles of Naval Architecture, “the external rolling forces due to waves and wind tend to distort the relationship of [Equation 2]. Hence, caution must be exercised in calculating GM values from periods of roll observed at sea, particularly for small craft” (Goldberg, 1988). That is to say, the GM metric is not truly GM, rather a wave and wind influenced value based upon an estimate for calm-water GM.

The roll period calculation is based upon time between zero up-crossings. For both the period and GM estimates, the user may provide minimum and maximum values outside of which they wish to be warned of anomalous behaviour; additionally, monitoring trend behaviour can be indicative of emergent issues.

SCraMP motions are reported and recorded using both Tait-Bryan angles, which correspond to the common phrases of “roll,” “pitch,” and “yaw” used when describing boats or aircraft, and a more classic Euler angle representation.

To verify the accuracy of SCraMP as a data acquisition system, sea trials were conducted aboard a 19’ Carolina skiff, in the Willoughby Bay of Virginia in calm seas, essentially sea state 0. The time history gathered for this analysis represents just over 1,300 seconds (21.7 minutes) of data. Figure 2(a) shows excellent agreement between SCraMP’s location information and the GPS position provided by a Garmin GPS. Similarly, Figure 2(b) shows strong agreement between the heading output from an HMR3000 versus both heading and course over ground as reported via SCraMP. Note, heading in SCraMP is determined through the use of the device magnetometer, whereas course over ground is based upon GPS information. As such, there is no course over ground information when relatively stationary, as was the case for the first portion of this time history.
Figures 2(c) and (d) provide roll and pitch time histories respectively. Generally speaking, the agreement/discrepancies between the roll and pitch time histories are as expected based upon the differences in sample rate (SCraMP nominally at 50Hz, HMR3000 at 5Hz) and published hardware specifications; see for example (Honeywell, 2006) and (STMicroelectronics, 2010). In particular, the author hypothesizes that the dynamic response rate of the hardware used in the iPhone is higher than that of the HMR3000. This is not inconsistent with the published specifications for the HMR3000 (Honeywell, 2006) and the STMicroelectronics L3G4200D used in the iPhone (STMicroelectronics, 2010). There does appear to be a yet unidentified either drift present in the iPhone data or trending toward the mean value present in the HMR3000 data. Anecdotally speaking, the truth likely lies somewhere between these two hypotheses. That is, even with the
motion of the operator aboard such a small craft, it seems unlikely that there was 5 degrees of roll and pitch difference between the beginning and ending of testing. That said, there was indeed a pitch event at the end of the data collection run, which only appears in the SCraMP data. The author believes some of this variation is due to the point at which the data acquisition systems were mounted on the vessel, near the stern, subject to motor vibrations. A more rigid mounting system would perhaps alleviate some amount of discrepancy. For further discussion, as well as automobile and laboratory comparisons of the two hardware approaches, refer to McCue (2012b).

Figure 2(c): Sea trial comparison of SCraMP versus HMR3000 roll motions.
Figure 2(d): Sea trial comparison of SCraMP versus HMR3000 pitch motions.

For a detailed look at the motivation and history behind SCraMP, the interested reader is referred to McCue (2012a).

**SCRAMP—ASSESSMENT**

As part of an initial assessment effort for SCraMP, the author presented a tutorial on the use of the app at the Commercial Fishery Trade Show (ComFish) in Kodiak, Alaska, in April of 2012, the Pacific Marine Expo in Seattle, Washington, in November of 2012, and at the Ferry Transport Committee’s Midyear Conference and Meeting in New York City in August of 2012. In each of these venues potential users were allowed to test the app on demonstration devices. The survey appearing in Appendix A of this paper was distributed to those desiring to test the application. Results of this survey are presented as follows.

Responses to the demographic questions posed on the survey are shown in Figure 3. The majority of the respondents were white, non-Hispanic, males. Of the respondents, 53% were age 45 or older; 47% were 44 or younger. Commercial fishers were the largest single demographic represented; this was the initial target demographic for the app as demonstrated by participation in ComFish and the Pacific Marine Expo. These demographics are not uncharacteristic of the Alaskan commercial fishing industry per comparison to Sepez et al. (2005) with the primary difference being the relatively high response rate in an older demographic than is characteristic of the population. This likely reflects a higher participation in the survey by vessel captains/owners/operators rather than deck hands.

In Figure 4 we observe that the survey respondents valued each screen of data with the location screen having the strongest favourable response followed by the gyroscope and record screens. It should be noted that a recent iOS update required removing access to NOAA buoy data from the location screen, thus it is to be seen as to if this favour for the location screen remains with that feature removed.
Figure 3: SCraMP Survey Respondent Demographic Data
Figure 4: SCraMP Survey Respondent Feedback on Use of Each Screen and GUI
Figure 5 shows that all safety metrics were valued by those surveyed with a slight preference for the index-based metric.

Figure 6 shows survey respondents’ perspectives on hypothetical operations with SCraMP. While the majority of respondents were undecided as to if SCraMP would be useful when making operational decisions, 74% of respondents agreed or strongly agreed that operations would be safer when running SCraMP.

Figure 7, uncorrelated to the survey, provides a worldwide map of current SCraMP application users. While users are predominantly based in the United States, downloads have been recorded around the globe.
FVDRILLS—DESCRIPTION

In support of this app-based approach to maritime occupational safety interventions, the author teamed with the Alaska Marine Safety Education Association (AMSEA) to develop a drill checklist app with sample drills for person overboard, fire on board, flooding, and abandon ship, along with a vessel safety orientation. At the time of the app’s release in early February of 2013, the drills provided were taken largely verbatim from the AMSEA produced book *Beating the Odds on Northern Waters* (Jensen and Dzugan, 2009). Sample screen captures are provided in Figure 8 and a world map depicting locations of FVdrills users is given in Figure 9. As can be seen, in a very short time, FVdrills was adopted by users on six continents.

The importance of conducting monthly drills has been recognized by regulatory agencies. For example, the United States Coast Guard requires an appropriately trained fishing vessel drill conductor aboard each vessel operating outside the boundary line to ensure that each crew member participates in monthly drills and is appropriately trained in abandoning the vessel, fire fighting (including donning appropriate gear), recovering a man overboard, minimizing the effects of flooding, donning survival gear and launching survival craft, making distress calls, activating the general alarm, and reporting inoperative alarms (CFR 28.270). It is the philosophy of the author that enabling portability for meeting these requirements will encourage compliance as maritime workers find that adopting to the life-saving regulations is both low-cost and improves safety.
It is hoped that the author and the partner AMSEA will be able to develop FVdrills into a truly interactive tool with features to:

- Enable local and remote logging of drills
- Allow for signature and time/date stamping of drills
- Provide realistic, interactive, prompted drill transitions from say, a fire on board drill into an abandon ship drill
- Provide localizations enabling crew participation across language barriers
- Amongst other user driven improvements…

![Figure 8: Sample screen captures for FVdrills](image-url)
CONCLUSIONS

The basic goal of this assessment effort was to determine if portable electronic devices could serve as occupational safety intervention tools in the maritime industry. The result of the SCraMP assessment indicated sufficient potential to warrant the development of a second maritime safety app: FVdrills. In future research it would be ideal to do a more extended assessment effort by distributing a large number of devices with both apps pre-loaded to maritime workers for use over the duration of a ‘typical’ season for their industry. Additionally, for FVdrills, increased interactivity and downloadable logging capabilities are needed, based upon anecdotal user feedback to date. Localizations of both applications into multiple languages may assist with user adoption, particularly for FVdrills in which potential users aboard a single vessel may have different native languages.

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REFERENCES


APPENDIX A: SCRAMP USER SURVEY

Gender
☐ Male  ☐ Female

Age
☐ 18-24  ☐ 25-34  ☐ 35-44  ☐ 45-54  ☐ 55-64  ☐ 65+

Race
☐ American Indian/Alaska Native  ☐ Asian  ☐ Black or African American  ☐ Native Hawaiian or Other Pacific Islander  ☐ White

Ethnicity
☐ Hispanic or Latino  ☐ Not Hispanic or Latino

How would you use SCraMP (check all that apply)?
☐ Commercial Fishing  ☐ Fireboat  ☐ Law Enforcement  ☐ Military: Big Boat >100ft  ☐ Military: Small Boat <100ft
☐ Recreational Boating  ☐ Research & Development  ☐ Test & Evaluation  ☐ Commercial Vessel: 6-pack  ☐ Commercial Vessel: <100 ton
☐ Commercial Vessel: <200 ton  ☐ Commercial Vessel: <500 ton  ☐ Commercial Vessel: >500 ton  ☐ Other:

SCraMP will be useful when making operational decisions.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

Operations will be safer when running SCraMP.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s graphical user interface is intuitive and easy to use.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s “Accelerometer” screen and features are useful to me.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s “Gyroscope” screen and features are useful to me.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s “Safety Metrics” screen and features are useful to me.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s “Location” screen and features are useful to me.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

SCraMP’s “Record” screen and features are useful to me.
☐ Strongly agree  ☐ Agree  ☐ Undecided  ☐ Disagree  ☐ Strongly disagree

Amongst the safety metrics in SCraMP, which will you use (check all that apply)?
☐ Index  ☐ GM  ☐ Period
Is there a safety metric you want included in SCraMP?

Are there other iPhone/iPod tools or features you want SCraMP to incorporate?

Did SCraMP ever crash or otherwise exhibit unstable behavior? If so, please describe the occurrence.

Do you have any recommendations for future versions of SCraMP?

Do you have any general comments for the developers of SCraMP?