13.1 Background and Evolution of the Cuscore in Control Chart Monitoring

Statistical process control (SPC) has developed into a rich collection of tools to monitor a system. The first control chart proposed by *Shewhart* [13.2] is still the most widely used in industrial systems [13.3]. As observational data from the system are plotted on the chart, the process is declared "in control" as long as the points on the chart stay within the control limits. If a point falls outside those limits an "out of control" situation is declared and a search for a special cause is initiated.

Soon practitioners realized that the ability of the Shewhart chart to detect small changes was not as good as its ability to detect big changes. One approach to improve the sensitivity of the chart was to use several additional rules (e.g., *Western Electric rules* [13.4] that signal for a number of consecutive points above the center line, above the warning limits, and so on). Another approach was to design complementary charts that could be used in conjunction with the Shewhart chart but that were better at detecting small changes. *Page* [13.5] and *Barnard* [13.6] developed the cumulative sum (Cusum) chart where past and present data are used in a cumulative way to detect small shifts in the mean. *Roberts* [13.7] and *Hunter* [13.8] proposed the exponentially weighted moving average (EWMA) as another way to detect small changes. This ability comes from the fact that the EWMA statistic can be written as a moving average of the current and past observations, where the weights of the past observations fall off exponentially.

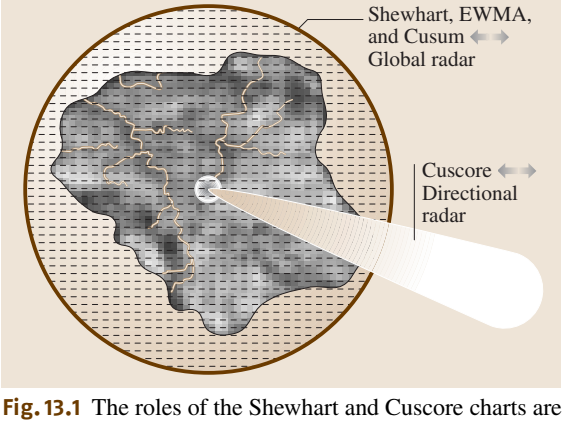

Fig. 13.1 The roles of the Shewhart and Cuscore charts are compared to those of global and directional radar defenses for a small country

Of course the Shewhart, Cusum, and EWMA charts are broadly applicable to many types of process characterizations. Remarkably, the Cuscore chart generalizes the Shewhart, Cusum, and EWMA charts; however, its real benefit is that it can be designed to be a high-powered diagnostic tool for specific types of process characterizations that are not covered by the basic charts. We will develop this result more formally after introducing the Cuscore theory. However, an analogy due to *Box* [13.9] will help to establish the ideas.

Suppose a nation fears aerial attack. As Fig. 13.1 shows, a global radar scanning the full horizon will have a broad coverage of the entire border, but with

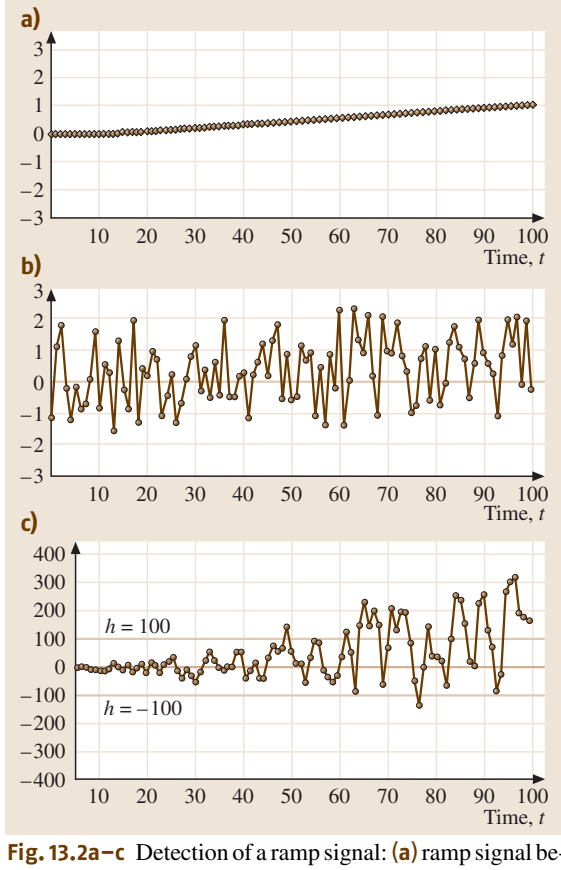

Fig. 13.2a–c Detection of a ramp signal: **(a)** ramp signal beginning at time 10; **(b)** the signal plus white noise consisting of 100 random normal deviates with zero mean and standard deviation $\sigma = 1$; and **(c)** the Cuscore statistic applied to the data of **(b)**

http://www.springer.com/978-1-85233-806-0

Springer Handbook of Engineering Statistics
Pham, H. (Ed.)
2006, XLIV, 1120 p. With CD-ROM., Hardcover
ISBN: 978-1-85233-806-0