Those who closely follow GPS are undoubtedly aware of what Dr. Brad Parkinson has been saying, for some time now, about ability to continue operation even as SVs are aging. We can do it if we design for it. To be sure, there are challenges. Page 6 of June`09 GPSWorld shows phrases such as GAO's "alarming report" – "shaky" – Gloomy Outcomes" – and more. Right on the heels of that, the top of page 8 has another article discussing problems with the recently launched satellite. It is stated that "The Air Force won't launch any further satellites until this issue is resolved." Even after that, the aging problem will continue to limit performance of present methods for at least two years. Among other problems, RAIM availability will be reduced and cycle ambiguity resolution – already vulnerable to occasional catastrophic error – will be less dependable. Subsequent issues of GPSWorld (Feb, Mar, and Apr 2010) describe further problem areas. The latter notes that, while more satellite constellations will help, future jamming prospects will forever preclude guarantees. But *solutions are available*.

Clearly the situation calls for high priority attached to robustness. Ability to operate under adverse conditions is essential – but much is missing from current practices. Today's approaches have served well in myriad operations thus far, with overabundant satellite measurement data. As that abundance erodes, solutions must fully exploit well-known – and some lesser known – ways to extract information from all available data. Even many well-known approaches are only partially applied, and operation with lesser known methods is either extremely rare or nonexistent.

The whole focus of Dr. James L. Farrell's recent book *GNSS Aided Navigation and Tracking* is centered on a host of flight-validated robustness features. Current events now provide motivation to offer online inspection of it. Features listed below can be seen and verified from book pages cited; many can be freely viewed (though not downloaded nor printed) on this site:

- full usage of any number of signals (all the way down to one) from *any* constellation, *any* frequency
- sequential change in carrier phase, inherently invulnerable to ambiguity (*pp.* ix-x), can stand alone – i.e., with no ground receiver needed (*pp.* 101-105; note table on *p.* 104)
- usage of carrier phase that is discontinuous (*pp.* 24 and 78), with the data type just described
- flexibility and interoperability in preparation for GNSS (e.g., *p.* 4, *pp.* 144-145, *p.* 229)
- geometry-independent single-measurement RAIM (*pp.* 121-126, see footnote on *p.* 122)
- major simplification of inertial error propagation (*p.* 20, Chapter 4, and *pp.* 98-99), while still maintaining universal applicability of long-term navigation equations (Chapter 3 and Appendix II)
- means for addressing inertial instrument errors in considerable depth (*pp.* 57-66; 244-245)
- wander azimuth easily handled with no risk of numerical error (*p.* 32)
- state-of-the-art dynamic performance in low-cost tightly coupled GPS/INS van test (*pp.* 162-170) and flight test (*pp.* 171-181), using algorithms shown for step-by-step navigation in Chapter 3, error propagation modeling in Chapter 4, GPS differences in Chapter 5, and integrity tests in Chapter 6
- velocity accuracies of order cm/sec with IMU; decimeter/sec in flight test with no IMU (*pp.* 154-161)
- extensive coverage of tracking (Chapters 2 and 9), illustrating the close relation of error propagation for tracking and inertial navigation (e.g., end of *p.* 20); exploitation of the relation between block and recursive estimation, accounting for inevitable real-world model imperfections (Chapter 2)
- means for major advance in collision avoidance (*pp.* 218-219) by providing messages from existing Mode-S squitters transmitting measurements (rather than coordinates)
- extended scope of the squitter message types to share observations from nonparticipants (*pp.* 203-204), producing unprecedented situation awareness
- similarities and differences among tracking applications; related operations (*pp.* 6 and 206-223)
- consistent notation (Appendix I)

The last chapter (Chapter 10) finally envisions a truly integrated "system of systems" where the methods and concepts presented are carried to their logical conclusion. The last appendix (Appendix III) then addresses myriad practical issues involved in their adoption.