APPENDIX C

ADDITIONAL POTENTIAL BENEFITS OF TIGHTLY COUPLED GNSS/INS

The following sections discuss some other potential benefits of tightly coupled GNSS/INS systems. Some of these potential benefits are rather speculative at this point, but discussed here to show the longer term potential for GNSS/INS.

1. APV 1

1.1 Initial simulations indicate that with a full GPS constellation, and in normal ionospheric conditions, but without benefit of SBAS, a tightly coupled system will be able to exceed the requirements for APV 1 listed in Table B-1 below. The outstanding issues are the trade-spaces between:

a) Robustness to ionospheric activity and availability.

b) Integrity and ionospheric activity detection.

Table B-1 APV 1 performance parameters

Accuracy, Horizontal 95%	16 m (52 ft)
Accuracy, Vertical 955	20 m (66 ft)
Integrity	$1 - 2 \times 10^{-7}$
Horizontal Alert Limit	40 m (140 ft)
Vertical Alert Limit	50 m (164 ft)
Time-to-Alert	10 sec
Continuity	$1 - 8 \times 10^{-6}$
Availability	0.99 to 0.99999

2. GBAS

2.1 The EC is currently sponsoring the GNSS Inertial Future landing Technology (GIFT) program. The objective of the program is to demonstrate how GBAS and INS can improve Autoland and CAT III capability. The 30-month program is currently in its 8th month. The areas in which it currently appears that INS can improve the performance of GBAS are as follows:

2.2 Availability

2.2.1 Availability is improved by tight-coupling's ability to coast through the final stages of an approach/landing. The significance of this capability is that critical satellites cease to be an issue. This automatically increases availability.

2.3 Continuity

2.3.1 The coasting availability of tightly-coupled systems provides a complete solution to any remaining continuity issues for GBAS.

2.4 Time-to-alert

2.4.1 As described above, tightly-coupled systems do not use GNSS (or GBAS) data in real time. Consequently, Time-to-alert for the GBAS element can be considerably relaxed. For a GBAS/INS CAT III system, it would be perfectly acceptable for the GBAS element to operate with a 10 second time-to-alert. To take advantage of this feature would require an aircraft architecture that fail/op voting of the tightly-coupled GBAS/INS aircraft element of the system.

3. SBAS

3.1 The potential for improvement of SBAS performance using tight-coupling is less clear. The categories of benefit the same as those described above for GBAS. However the power spectral density of residual SBAS errors may have a relatively larger low frequency content than GBAS. The more relatively significant the low frequency content, the more limited the ability of tight-coupling to improve VPL and LPL. Further study is required.

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