CCSDS 2004 SPRING MEETING

ESA HQ, Paris, France

May 6-7, 2004

SLS Ranging Working Group - Minutes of the Meeting

1. Action items review

AI_03-01, AI_03-02, AI_03-03 and AI_03-05 have been completed and inputs received for discussion at this meeting.
Concerning AI_03-04 (review summary of available ranging techniques) with due date after the meeting, GSFC position is to accept any proposals by JPL. It was therefore proposed and accepted to remove the GSFC representative from the action item. A new date of 15 September was agreed for such action so as to have the results available prior to the next meeting.

2. Delta-DOR recommendation

Recommendation 2.5.6B was reviewed in light of the results of AI_03-05 and input paper RNG_04-01.
The changes proposed by the chairman after an e-mail exchange with J. Border/JPL (the author of the current 2.5.6B) were agreed.
Discussion continued with the proposal for adding low-frequency tones generated by filtering a squarewave, for those missions with digital transponders and not so stringent accuracy requirement. The proposal contained in document RNG_04-01 was accepted.
The revised rec. 2.5.6B was approved for agency review.
Action AI_04-01 was given to run simulations of filtered square-wave tones and check the spectral regrowth at a saturating amplifier's output.

3. Current ranging recommendations

Recs. 2.5.4A and 2.5.4B were discussed as per input document RNG_04-02. Recommends 2 and 3 of 2.5.4A are not met by most European transponders. AI_04-02 was given to GSFC to find out if recommends 2 and 3 are still applicable. A similar discussion took place on rec. 2.5.4B, which is based on a 1 MHz clock component. Whereas JPL documents allow chopping, which could solve the problem of recommends 2, 3 and 4 for European transponders, the actual range of chopping used was not available. AI_04-03 was given to JPL to clarify the chopping normally used.
In light of the current planning for a European ranging standard, the GSFC and JPL delegates very kindly agreed to try and complete their action by May 21, 2004.

4. Regenerative ranging

This session started with the presentation of paper RNG_04-06 by JPL.

The paper shows that the current (non-regenerative) JPL sequential ranging can reach a 1 ns accuracy with the 1 MHz clock component. The next generation transponder to be developed by 2010 will also include regenerative PN ranging capability up to 2 Mc/s, which corresponds to 1 MHz clock component. The paper is based on the PN ranging system included in JPL 810-5 although the capability is not implemented at this stage. The composite code is 1,009,470 chips long (2x7x11x15x19), which at 1 MHz gives 75,000 km of ambiguity. Also a non-regenerative PN code is given.
The spectrum in JPL paper appeared to be different from ESA simulations based on 810-5 and action AI_04-04 was taken to try and understand the cause for the differences.

Paper RNG_04-03 by Prof. Massey (supporting ESA) was introduced. The paper analyzes from a theoretical point of view the performance of JPL regenerative code as in 810-5, of two variations thereof, as well as of a completely different code (GHM) proposed by Prof. Massey. During discussion of the paper, it turned out that Prof. Massey and JPL made two different assumptions for the probability of erroneous acquisition. AI_04-04 was taken to recompute the acquisition time for the same probability as in JPL computations.
The correlation loss of JPL code for Ci with i>1 is approximately 26 dB. Modifying JPL code by giving 4 votes to C1 is similar to the original Titsworth work and yields very little reduction of the clock (C1) correlation but a big improvement on the other components correlation thus halving the acquisition time.
If instead 2 votes are given to C1, the clock component is reduced by 3.6 dB but the other components are 12 dB higher and the total acquisition time is 32 times shorter than with JPL code.
The alternative GHM code is 1,310,720 chips long ($2*10^{16}$) and can be acquired very rapidly. The resulting spectrum is however very flat and could potentially interfere with telemetry and telecommand as well as adjacent channels.
AI_04-06 was taken by JPL to analyze and comment ESA's proposal.
Since the work by Prof. Massey is not finished yet, ESA took the action to provide CCSDS with the final report including spectral plots and filtering if any (AI_04-07).

Due to the good progress achieved so far, the WG expects to meet its charter deadline of July 2005.

Paper RNG_04-05, response to action items AI_03-01 and AI_03-02, was presented. Conclusions of the discussion with J. Berner (JPL) are that the acquisition time depends on the selected parallel/serial acquisition implementation as well as on the probability of acquisition and false detection. Berner's paper is for a fully parallel station acquisition with 76 correlators. That's why the basic code acquisition does not have to be multiplied by 23 to obtain total acquisition time. The assumed false acquisition probability by Berner was unknown while the probability of acquisition was 0.999.

Paper RNG_04-04 on PN ranging requirements was presented. Such papers give preliminary requirements on the transponder to provide both transparent and regenerative PN channels by using the same modulation and possibly codes. Preferred chip rates in the range 1-2 Mc/s have been identified to meet the BepiColombo 20-30 cm accuracy.

AI_04-08 was taken to asses the RF interference between the proposed PN codes and both telecommand and telemetry links.
AI_04-09 was taken by JPL to check if any number could be used for the chip rate/carrier frequency ratio on top of the ratio given in 810-5.
Discussion on ranging with suppressed carrier telemetry lead to the conclusion that only a white book could be delivered on this subject with the present charter.
AI_04-10 was taken to try and specify transponder requirements in terms of linearity and gain flatness, 3-dB bandwidth, group delay variation, etc.
AI_04-11 on ESA was taken to report on acquisition performance as measured on the BepiColombo breadboard below 27 dBHz for the various Titsworth schemes identified in Prof. Massey's paper. It was agreed to use Pcorrect acquisition = 99% and to try and go as low as 10 dBHz if possible.

5. Resolutions

The WG resolves to submit revised rec. 2.5.6B for agency review.

Annex 1 - Action Item List

AI #	AI description	Actionee	Due date
AI_03-04	Propose a review summary of available techniques for ranging	G. Boscagli D. Lee	15.09.04
AI_04-01	Run simulations of filtered square-wave delta-DOR tones via saturated amplifier and compute spectra	D. Lee G. Boscagli	2 weeks prior to next meeting
AI_04-02	Check if GSFC ranging system requires recommends 2 and 3 in 2.5.4A	V. Sank	21.05.04
AI_04-03	Check lowest chopping frequency in relation to 2.5.4B	W. Martin D. Lee	21.05.04
AI_04-04	Try to align the PN ranging spectra of 810-5 and ESA's simulations (line at 2 MHz for 1 MHz squarewave)	E. Vassallo D. Lee	2 weeks prior to next meeting
AI_04-05	Compute the acquisition times for the same probability of false acquisition as JPL	J. Massey	2 weeks prior to next meeting
AI_04-06	Review the three ESA's proposed codes of paper SLS-RNG_04-03	D. Lee	2 weeks prior to next meeting
AI_04-07	Provide final report of the ESA study upon completion including spectral plots and filtering if any	E. Vassallo G. Boscagli	2 weeks prior to next meeting
AI_04-08	Analyze the RFI of all proposed PN ranging schemes with TC/TM	D. Lee G. Boscagli	2 weeks prior to next meeting
AI_04-09	Check if any number can be accepted for the carrier-to-chip rate ratio for DSN	D. Lee	2 weeks prior to next meeting
AI_04-10	Proposed figures for XPND linearity, gain flatness, 3dB bandwidth and group delay variation for the selected PN ranging scheme(s)	D. Lee G. Boscagli	2 weeks prior to Spring 2005 meeting
AI_04-11	Report on acquisition test results on BepiColombo breadboard from 10 dBHz (TBC) to 27 dBHz for the 3 Titsworth schemes identified	G. Boscagli	2 weeks prior to next meeting

Annex 2 - List of Participants

Name	Affiliation	e-mail
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Annex 3 - List of Input Papers

	Ranging WG: Paper Title	Distributed	Author
RNG_04-XX			
01	Delta-DOR recommendation - proposal for change (Rec. 2.5.6B)	y	G. Boscagli, E. Vassallo
02	Ranging transponder bandwidth for residual carrier systems, Category A and B (Rec. 2.5.4A and 2.5.4B)	y	B. Smeds, E. Vassallo
03	Study on PN ranging codes for future missions	y	J. Massey
04	PN ranging requirements (AI_03-03)	y	G. Boscagli
05	Clarifications on NASA/JPL PN ranging codes	y	G. Boscagli
06	JPL regenerative ranging	y	D. Lee

Annex 4 - Agenda

Date	Item		AI	Actionnee / Author	Comments / Input Papers
Thu 6, a.m.	5	RNG action items review		All	
	6	Regenerative ranging		D. Lee	RNG_04-06
				J. Massey	RNG_04-03
			RNG_03-01/02	G. Boscagli	RNG_04-05
			RNG_03-03	G. Boscagli	RNG_04-04
Thu 6, p.m.	7	Ranging and delta-DOR		E. Vassallo	RNG_04-02
			RNG_03-05	G. Boscagli	RNG_04-01
Fri 7, a.m.	8	Contingency/RFM&RNG wrap-ups			
Fri 7, p.m.	9	SLS plenary		J.L. Gerner	