final report

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Auto Beef Banjo removal

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Executive Summary

On Friday August 6th 2010, John Hughes and Sean Starling attended Teys Beenleigh beef processing facility to continue developments of a fully funded AMPC/MLA Technology project known as Automated Beef Banjo boning contracted through RTL.

The aim of the day was to pay particular attention to the process of marking (i.e. cutting) the scapula bone prior to mechanical meat removal. This was a focus as a result of trials that John, Sean and others had completed a few weeks earlier at a Silver Fern Farms Pacific processing plant.

Using a purely black and white fail/pass measure of the outcomes of the August trials, one would have to conclude that the marking trials where a failure although other outcomes and learnings have resulted through the execution of the August trials. RTL believe that AMPC/MLA need to now determine the best next steps for their investment, with input as requested being provided by RTL.

RTL believe that the questions that MLA/AMPC need to address are:

- What is AMPC/MLA trying to ultimately achieve strategically with its investment? and

Do the most recent developments hinder this ultimate outcome?

Contents

1.1 Background

This project is fully funded by the Australian red meat processing sector through AMPC and MLA. At the outset of the project the objective was to:

- Design and build proof of concept prototype to automate the removal of beef banjos addressing solutions for
  - Sensing
  - Cutting
  - Materials Handling
  - Integration.

Through various project meetings during the early phases of the project, the project was 're-scoped' or staged to focus initially on developing a device that could remove the scapula bone from the chuck tender and clod muscles.

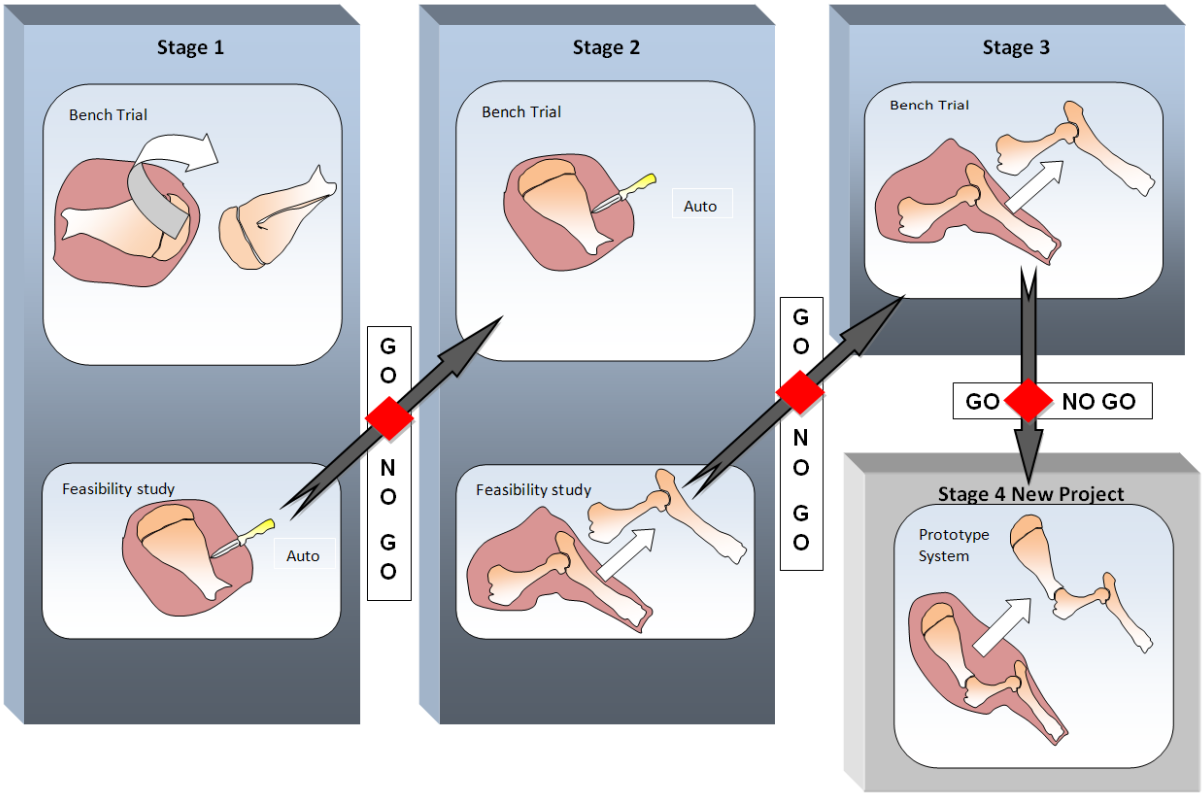


Figure 1: Re-scoped/Staged Project approach

The recent trials have had this one focus in mind.

1.2 R&D Risks

In each R&D project it is vital to understand the solution risks and hence have the R&D solely focused on mitigating these risks unless a high strategic purpose is identified. The following is an extract from the July trials which summarised the risks identified in July. No additional risks have been identified, or arguably mitigated during the August trials.

1.2.1 Material Handling (Risk 1 and 2)

The NZ trials demonstrated sufficiently that there where ways to hold the meat and bone. Although the holing mechanisms would benefit from additional development work and final design engineering, sufficient development had been undertaken and demonstrated in NZ to mitigate a large part of the material handling risk.

1.2.2 Force Required (Risk 3)

Sufficient force could be applied separating meat from bone using a pneumatic cylinder.

1.2.3 Clean Paddle Bone (Risk 4)

The removed paddle bone was as clean if not cleaner than what is typically achieved under the manual process, when marked adequately. Again proves the benefit of providing mechanical assistance to the boning operator. (**Benefit 1**) However initial marking and where required additional 'knife kicking' was required in some cases to obtain the increased yield.

1.2.4 Marking (Risk 5 and 6)

It was identified/further confirmed that marking at the commencement of the pull is a vital step. Due to the nature of each individual animal's life, there are occasions where the meat is tightly bound to the paddle bone at various other locations along the paddle bone. If not 'marked with a knife' the meat will begin to tear and result in poor/unacceptable yield recovery. Hence a solution needs to be developed that will ensure that if that any individual animal abnormality is allowed for. One discussion, although not necessarily agreed, was the use of mechanical blades and ploughs (aka DMRI) to closely follow the pulling action.

1.2.5 Carcase Anatomical Synergy (Risk7)

The 'ridge bone' on the paddle bone varies from animal to animal and at times hinders efficient meat removal. Sometimes the ridge bone is only vertical at others times the tip is 'rolled over' like and ocean wave, making it near impossible to cut/make with a simple straight cut.

1.2.6 Commercial Benefit (Risk 8)

On the assumption that Risks 1 to 7 inclusive are mitigated, does the output result in a solution that is (a) useable within a meat works and (b) increases the overall efficiency (labour, time, product presentation and yield) of the task(s)?

1.3 Possible solutions (Different approaches)

John has been considering other solutions to the problem for side chains in Australia to effectively replicate in the forequarter processing component of the boning chain, a mechanism that will invert the whole Banjo section as it is removed from the carcase side and enable a simpler banjo deboning process currently engaged on Australian and New Zealand quarter boning chains (**Alternative 1**)

Alternative 1 if successful will provide an immediate solution to the arduous nature of removing the paddle bone on Australian side chains, which is a positive and should be pursued. Alternative 1 will not necessarily progress RTL towards meeting MLA's project objective of automating the banjo removal and deboning process, however it may provide a processing benefit to side chains. By demonstrating to side chain operations this approach it may free the 'automated banjo' project team to re-focus and concentrate on the bigger audacious task of whole banjo de-boning.

1.4 Teys Trial Plan (Objectives)

MLA agreed for John and Sean to invest an additional day at Teys Beenleigh to:

1. Work at Teys Beenleigh and develop concepts on paper for Alternative 1
2. Work at Teys Beenleigh to identify how best to undertake trials and developments to mitigate Risk 4, 5, 6 and 7.
3. Provide David Doral, upon his return, a revised project schedule and budget for proposed further developments, if any at all.

1.5 Methodology

Teys Beenleigh was very accommodating to John and Sean and provided unlimited access to their boning room, boning room, supervisory and maintenance staff and product. The importance of this cannot be over emphasised.

On arrival John and Sean worked with Teys maintenance staff to modify a jig John had mostly completed whilst we was still at Teys.
The jig was similar to that used by the project team at SFF Pacific. In essence it enabled a scapula bonne with its two muscle groups (Chuck Tender and Clod) to be placed on a fixture and held in place whilst either the meat was removed from the bone or the bone removed from the meat. Refer Figure 2.

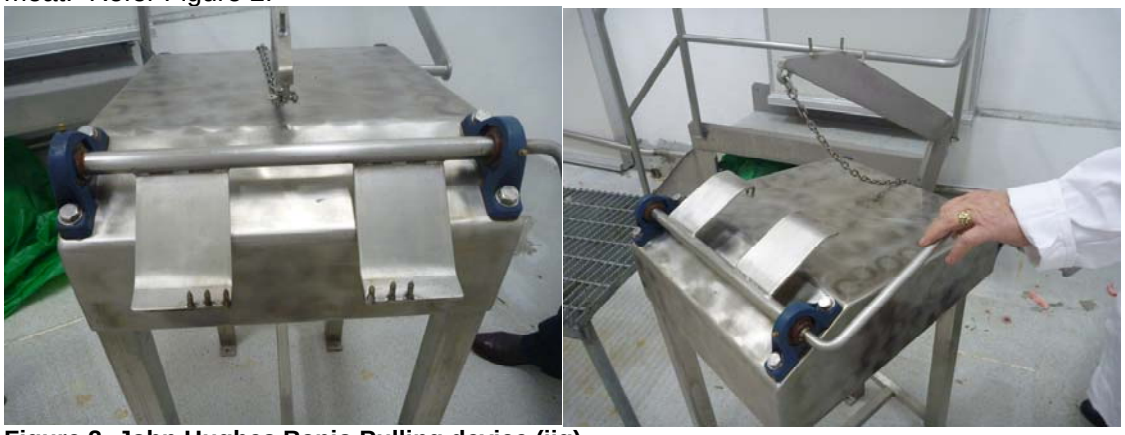


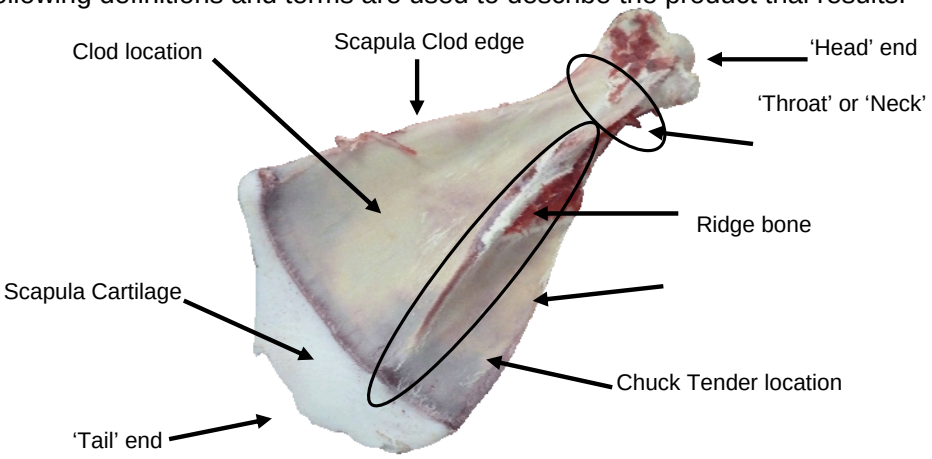
Figure 2: John Hughes Banjo Pulling device (jig)

Throughout the day multiple scapulas were removed from the boning rail and placed onto the machine. Special care was taken to ensure the clamps and chains did not interfere with any meat pulling and result in meat ripping in an equivalent way that poor marking reveals itself.

Multiple marking techniques where tried to prepare the banjo for machine loading. Alternative approaches of no 'on the fly' and some 'on the fly' marking was tried during machine activation. Note on all trials the scapula clod edge and scapula chuck tender edges were marked (i.e. cut clear with a knife).

1.6 Product Nomenclature

The following definitions and terms are used to describe the product trial results.



1.7 Results

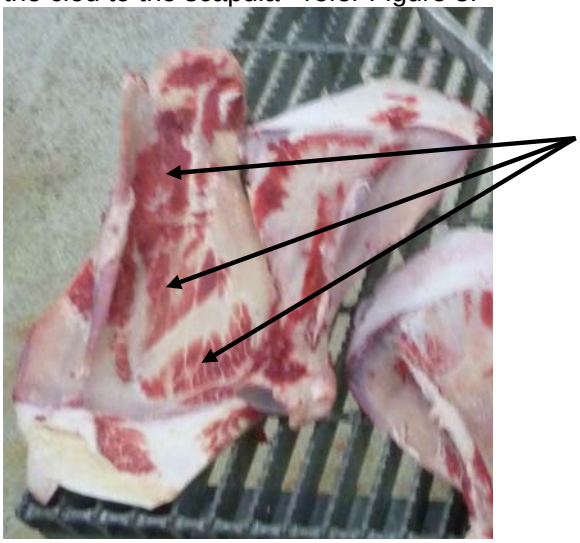
The trials are reported in batches relating to their marking or pulling configuration

1.7.1 Trial Set One – Marking the neck area only.

Trial 1 was very successful and ultimately led to the rest of the day being disappointing. These trials had only the **neck** area marked and the bone pulled away from the meat. The first banjo used under this method was removed with minimal effort and no yield loss – refer Figure 3. .

Figure 3: First trial - perfect outcome

Subsequent attempts of this approach resulted in yield loss along the ridge bone, when the ridge bone was curled over like a wave or losses when connective cartilage had joined the clod to the scapula - refer Figure 3.



Location of multiple muscle to bone connection points that did not exist on the first banjo trialed. Results in the muscle tearing rather than coming off the bone clean as achieved in Figure 2.

This problem appeared in more than half of the banjos trialed at Teys and at SFF.

Figure 4: Clod muscle with multiple scapula bone connection points

A positive outcome with a potential negative twist was that when successfully executed the clod and chuck tender were removed as a single piece. This single piece unfortunately contained some cartilage from the ridge bone – refer Figure 5. All determined that this cartilage would have to be removed by boning room trimmers prior to packing. The concluding concern was that although the approach significantly increase yield by delivering a one piece chuck tender and clod, there was a high probability that trimming staff would lose this yield by over trimming the cartilage.

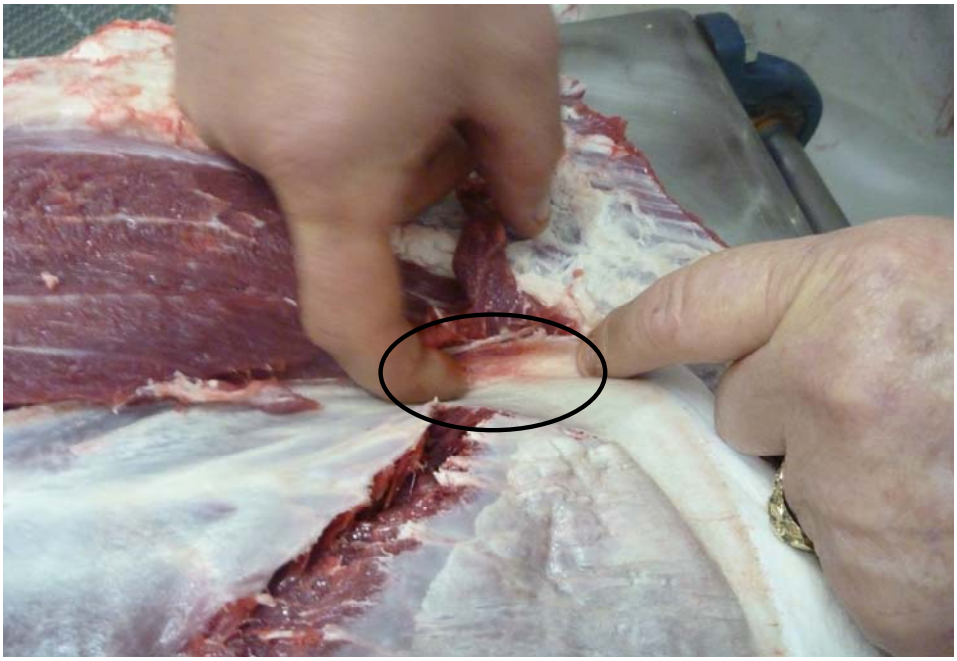


Figure 5: Additional Cartilage (circled) removed that would require trimming off

1.7.2 Trial Set Two – Marking the neck only and 'on the fly' marking.

The second batch of trials was executed in a way to attempt to overcome the issue identified in trial set one, where the muscle ripped when multiple muscle-bone connectivity point existed. This time the scapula was marked around the neck and placed onto the jig. As one person pulled on the deboning arm a Teys boning room staff member would, as quickly as possible, use a knife to free up any additional points where the muscle was connected to the scapula.

Where all parties could match communication with speed pulling and additional knifing activities a more repetitive and acceptable yield could be achieved. If one was to search for positives it could be concluded that if a machine was made to take the arduous nature away from this task a human could interact with it and ensure an acceptable yield recovery.

However the project team on the day felt that the speed at which the machine would be required to operate to enable a human to react and the process of marking prior to machine loading would prohibit this approach as a viable commercial solution.

The above still raises the questions of what additional mechanical blades, scrappers, ploughs, or CO2 systems could be used to work with a machine to overcome the issues of additional meat to scapula connection points.

1.7.3 Trial Set Three – Marking the neck and either side of Ridge bone.

The third batch of trials was executed in a way that included marking down either side of the ridge bone prior to machine loading. This method simulates the entire marking technique used by boning room staff.

The outcomes were various but generally disappointing. Firstly when the ridge bone was rolled over like a wave, a straight knife cut resulted in considerable meat loss left under the roll of the ridge bone, although no more that is seen in the manual approach.

Approach did not overcome the issue of lost yield due to multiple clod – scapula connection points.

1.7.4 Trial Set Four – Marking the neck and top of Ridge bone.

The fourth batch of trials was executed in a way that included marking down the top of the ridge bone prior to machine loading.

This approach in general did see the issue of the lost yield due to a rolled ridge bone remove. It made no difference to the yield loss of multiple meat-bone connection points

1.7.5 Trial Set Five – Cutting of the neck.

The neck of a bone was cut (refer Figure 6) to obtain an understanding if such an approach might make a difference. Although a trial was not formally undertaken with this approach the project team deduced that it was not going to overcome the multiple meat-bone connectivity points.

Figure 6: Cutting of the scapula neck

1.7.6 Trial Set Six – Pulling from the tail end

One trial was attempted whereby the pulling force was applied under the scapula cartilage end and roll the bone out from the opposite end to all other trials. The approach was not fully executed to completion and was aborted when it was apparent that pulling a large mass of meat at the start of the pull is not going to work. This is compared to pulling a smaller amount of meat at the commencement of the pull when the pull is commenced at the neck end.

1.7.7 Trial Set Anon – Pulling meat from bone

Various replications of the above approaches where trialled and the meat pulled from the bone. The conclusion in general was that it made little to no difference that the same marking approach but pulling the bone from the meat.

Theory would suggest that the better approach will depend on what the particular task will benefit from. Hence if a rigid fixation point and lever is required it is best to pull the bone from the meat. On the other hand if a hook fixture is best and more of a flexible peeling/rolling pulling approach is required then removal of the meat from the bone is a better approach.

1.8 Discussion

The main repeating hurdle seemed to be that where the banjo had additional connection between the clod and the scapula that was not just at the neck area then using the Teys and SFF pulling devices without significant operator 'on the pull' marking input, the yield loss was too great.

In general the circumstances when the ridge bone is rolled over does not appear to be a problem although will need consideration if ever a commercial machine is designed. The design considerations are twofold:

1. If a method of automatically performing 'on the pull' marking is engaged the 'rolling' of the ridge bone may be a hindrance.
2. If a system is designed to mark down either side of the ridge bone, a straight knife cut will result in yield loss.

It is interesting that when an operator performs this task on a boning room chain. The best way to describe the technique used by an operator is that they:

1. Mostly free the banjo from the side to an extent that it rotates 180 degrees resulting in the neck end point towards the roof.
2. The scapula is marked down either side of the bone (this might be done before 1 above)
3. The ridge bone is marked down either side
4. The chuck tender muscle is marked in a "V' shape against the scapula neck and the boner uses is boning room hook to 'flick' the muscle away from the scapula. 'Flick' here is used to depict a multiple jerking action of the bone on the hook during removal. Analogous to cracking a whip or dry fly fishing

5. Activity 4 is repeated for the clod.

This procedure appears to suffer less yield loss from the multiple bone-muscle connection points along the scapula.
Again the project team proved that a machine could apply manual assist and where the 'side was compliant' an increased yield resulted. With such a large number of non-compliant sides this task is either going to require an operator to interact with a machine or additional mechanical, or other, 'on the pull' marking solutions developed.

As a single manual assist task, removal of the scapula from the two meat muscle groups appears hard to commercially justify if a labour unit is still required. Maybe there is a justification for the use of a labour unit to operate a machine if that machine also removes all of the muscle groups from the banjo. It is Scott' understanding that this was one of the original aims of the project when approved by MLA.

1.8.1 Side boning chain can get quarter boning chain benefits

Whist at Teys as discussion was had pertaining to the ease at which quarter beef boning operational staff (aka SFF Pacific) had a less arduous job when undertaking the banjo boning unit operation than side boning chain staff (aka Teys).

As part of this discuss John and Sean worked with Teys staff to identify a possible approach and modification at Teys to remove the Banjo at the start of the boning chain and divert it to a small (but not existing) “banjo deboning rail”.

The benefit of this approach is that the banjo would be (a) inverted in the same orientation as a quarter chain and have gravity work for the boner during the deboning task and (b) the operator could be placed at the most optimum height for boning out.

A banjo was removed from a side and boned out in a way to replicate the process described above and the concept was proven.

John has recommended that Teys trial on one of their chains this design and trial it for a few months to evaluate the long term benefits of this approach.

1.9 Recommendations

This is one of those projects where on the surface it is hard to justify to keep investing in, albeit this is said with a black and white focus of solely automating the scapula removal from the clod and chuck tender muscles.
Taking a larger vision of striving to automate the beef boning room, one could argue that finding a solution to remove the problem of yield loss where a bone has multiple connectivity points with a muscle is going to be a key enabler for more than this specific application.

On the other hand, this issue may never be solved and developers moving forward may have to accept that they may always require operators to interact with machines, however those machines need to provide the operator with the ability to undertake more tasks than they can without the use of machines, or faster, or better yield, or a combination thereof. Hence there needs to be a sound commercial value proposition.

It would be valuable for this project and future beef boning developments to know why the ‘jerking/whipping’ removal action engaged by boning staff appears, without a substantial study being undertaken, to have a lower yield loss than a more mechanical continuous pull of a machine. Is the key to develop a machine that undertakes multiple pull-retract-pull cycles along the entire stroke of the machine to replicate this action?

A trial should be undertaken at Teys to understand the benefits of converting a side boning room to a ¼ - ¾ chain. Hence remove the banjo and process it in the inverted orientation on its own short boning chain.

1.10 Conclusion

AMPC/MLA needs to consider if the original aim of the project can still be met taking into account all of the outcomes AMPC/MLA was hoping to achieve.

There are still plenty of things that can be learnt on this topic that will advance beef automation, however this may not be the best time to undertake R&D for the sake of undertaking R&D from AMPC/MLA’s perspective.

At some stage in the future it is likely that a method (probably sensing and cutting combined) will be required to enable the removal of beef bones from muscles where there is an issue of multiple connectivity points.

There is an ideal Plant Initiated Project to be undertaken at Teys on developing, trialing and evaluating a ¼ - ¾ boning room configuration. Scott and RTL will provide any support deemed necessary by John, Teys and/or MLA.

1.11 Media

The video and photo set that accompanies this report is as follows:

Videos

- 2010-08-07 Banjo Marking trials #001
- 2010-08-07 Banjo Marking trials #002
- 2010-08-07 Banjo Marking trials #003
- 2010-08-07 Banjo Marking trials #004
- 2010-08-07 Banjo Marking trials #005
- 2010-08-07 Banjo Marking trials #006
- 2010-08-07 Banjo Marking trials #007
- 2010-08-07 Banjo Marking trials #008
- 2010-08-07 Banjo Marking trials #009
- 2010-08-07 Banjo Marking trials #010

- Photos
- 2010-08-07 Banjo Marking trials #001
- 2010-08-07 Banjo Marking trials #002
- 2010-08-07 Banjo Marking trials #003
- 2010-08-07 Banjo Marking trials #004
- 2010-08-07 Banjo Marking trials #005
- 2010-08-07 Banjo Marking trials #006
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- 2010-08-07 Banjo Marking trials #013
- 2010-08-07 Banjo Marking trials #014