Report from the 7th Meeting of the Accelerator Technical Advisory Committee for the Japan Proton Accelerator Research Complex (J-PARC)

February 28-March 1, 2008
JAEA
Tokai, Japan

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INTRODUCTION, SUMMARY, AND MAJOR RECOMMENDATIONS

The Accelerator Technical Advisory Committee (ATAC) for the J-PARC Project held its seventh meeting over the period February 28-March 1, 2008 at the JAEA site in Tokai, Japan. The committee heard presentations from project staff on February 28-29, held several closed sessions to discuss reactions and opinions, and presented a verbal report to project management on March 1. In addition the committee was given a comprehensive tour of the J-PARC facility. The meeting agenda is attached in the Appendix.

ATAC members in attendance at this meeting included: R. Garoby/CERN, D. Gurd/ORNL (retired), I. Hoffman/GSI, S. Holmes/Fermilab (chair), A. Noda/Kyoto, T. Roser/BNL, L. Young/LANL (retired), and J. Wei/BNL.

IAC members in at attendance at this meeting included: S. Henderson/ORNL

I. Gardner/RAL was unable to attend.

The committee heard comprehensive presentations covering all aspects of the project. Significant progress has been made over the last year on all fronts highlighted by the achievement of full energy beam commissioning of the RCS. The committee offers congratulations on these achievements to the entire J-PARC team!

The J-PARC project is now nearly complete with construction of the neutrino beamline the sole significant construction/installation activity remaining. Beam commissioning is well advanced in both the linac and RCS. Hardware commissioning is underway in the Main Ring, with beam commissioning scheduled to start in May. The schedule remains unchanged from that presented to the ATAC two years ago—an outstanding achievement. Startup of accelerator operations in support of the research program is expected in the 3rd quarter of JFY2008. As the construction project nears completion there remain several areas that the committee feels will require continued attention to assure a smooth transition to operations and full realization of the potential of the J-PARC complex:

- Planning for the upgrade of the linac energy to 400 MeV
- Main Ring performance
- Establishing rf accelerating systems in the RCS and MR sufficient to support long-term goals.
- Maximizing performance of the J-PARC complex over the first several years of operations.

These items are discussed in this report. Because of their importance to the successful completion of the J-PARC Project, and realization of the facility's ultimate performance, we have devoted individual chapters to both the linac energy recovery plan and to issues related to the rf accelerating cavities.

Finally, the ATAC wishes to express its appreciation to JAEA and KEK management and support staff for their hospitality during this meeting.

Summary and Major Recommendations

Linac
The linac has been in operations at its design energy of 181 MeV for more than a year. It is operating well and reliably, supporting commissioning activities both within the linac itself and within the RCS. The level of performance in the linac is sufficient to support initial goals within the J-PARC complex.

Comments and Recommendations

- Spares: The J-PARC staff has completed an analysis of the klystron spares requirements for the operations phase. The J-PARC staff is uncomfortable with a spares inventory of three. The ATAC agrees with their assessment (expectation is typically 2-3 klystron failures during a normal operating year).

  Recommendation: Bring the spares inventory up to ~5 as soon as possible, and negotiate a long-term agreement with Toshiba to maintain inventory at this level.

- Ion source: Performance of ion source is adequate for initial operations, but will require improvement for 1 MW (following the energy upgrade)
- Beam properties are mostly well characterized. However, tails in the vertical beam profiles are not understood. This needs to be tracked down (this is probably a mismatch)

  The committee feels the lack of bunch length monitoring within the linac needs to be rectified.

- The beam chopping scenario required to support full power operation remains to be demonstrated.

Linac Energy Upgrade Plan
The linac energy upgrade will restore the 400 MeV linac capability that was included in the original scope of Phase 1 of the J-PARC project. The total cost of the energy upgrade is approximately 90 Oku-yen. The upgrade includes the construction of 21 acceleration modules, two buncher modules, and two debuncher modules. The modules all utilize (room temperature) annular coupled structures (ACS). To date two annular coupled structure (ACS) buncher modules have been fabricated and tested at high power, and one low beta accelerating module has been fabricated and characterized at low power.

Comments and Recommendations

- The ATAC is concerned that there is insufficient vacuum pumping on the module. (Evidence: 12 hours to get up to full power on the buncher, which could be significantly longer in the accelerating modules (which are longer))

- A “feature” of the ACS is that it is impossible to tune the accelerating cavities after brazing. Manufacturing errors then manifest themselves as “field tilt” in the cavities. However, the low beta module tested is probably usable as is.

  Recommendation: Establish specifications for the measurements of frequency in the stack assembly prior to brazing that will result in a structure with the accelerating and coupling cavity frequencies within specifications.

  Recommendation: Think about implementing a method of fine-tuning the coupling cavities after the module is brazed.

- Longitudinal beam profile measurement will be essential for matching the beam from the SDTL to the ACS.
- The 972 MHz Klystron is under development, with three units produced and tested. All have stability problems
- The ATAC feel that modulating the output of the klystrons at 1.2 MHz to compensate for beamloading at the chopping frequency may not be such a good idea. (Danger is exciting a nearby mode(s) in the accelerating structure.) The observed instability is possibly related to the large bandwidth required for the 1.2 MHz modulation.

  Recommendation: Reevaluate whether 1.2 MHz modulation of the power is really needed.

- The ATAC suggests reconsideration of the type of accelerating structure, including superconducting or side coupled, for the energy upgrade <u>if</u> funding is delayed by a year or two
- The ATAC is convinced that the full potential of the J-PARC complex cannot be realized with a 181 MeV linac.

  Recommendation: The ATAC continues to urge the identification of funding for restoration of the linac energy to 400 MeV as a high priority item.

3 GeV Rapid Cycling Synchrotron Status & Commissioning Plan

Great success has been achieved in beam commissioning in the RCS. Beam commissioning was initiated in early October and 3 GeV accelerated beam established by the end of the month, ahead of schedule. The RCS is working well at low intensities and many aspects of the beam and lattice properties are well characterized. The RCS was successfully operated for several minutes at a beam power of 50 kW, with a single bunch. The RCS is prepared to support beam commissioning in the MR, scheduled for May. Congratulations are offered to the entire RCS team on these fine accomplishments!

<u>Comments and Recommendations</u>

- The expectation is that the current configuration will support 300 kW operations in 2009.

- Losses: Beam loss of 6% is observed at roughly 10% of nominal intensity in the RCS. This is done with an unpainted beam. The Committee feels it is important to understand the source of this loss. Possibilities might include space-charge (since the beam is not painted), optics mismatches, leakage from the rf bucket, and/or extensive foil interactions.

  Recommendation: Continue the commissioning studies with injection painting to explore higher intensity operations.

  Recommendation: Continue to utilize the integrated tracking simulations as an aid to evaluating the loss budget.

  Recommendation: Implement local correction of the leakage fields of the RCS septa.

- Collimators: The ATAC continues to be concerned about how losses are distributed on the collimators.

  Recommendation: Prepare an improvement plan for the RCS collimator system that provides sufficient margin to cope with realistic operations scenarios.

- Extraction Kicker: The required field flatness has been achieved by adjusting the relative timing of the kicker modules

  Recommendation: Perform tests with beam to show whether the RCS kicker risetime is sufficient for full power operation.

  The J-PARC team is investigating coating of the kickers as a means to suppress secondary electron emission (as recommended by the ATAC).

  Recommendation: Prepare for coating the Ferrite and aluminum surfaces of the extraction kicker. Coating with TiN was successfully achieved for the SNS project.

  The kicker impedance remains at a level that could lead to instabilities at the design beam power levels.

  Recommendation: Prepare a plan to address beam instabilities caused by the large kicker impedance.

- The ATAC suggest that closed loop operation of the rf system with beam should be commissioned as soon as possible.

- Capacitors have failed on the ceramic beam pipe in the vicinity of the injection bump magnets. The J-PARC staff need to understand the cause and find a permanent solution.

Main Ring Synchrotron Status & Commissioning Plan
MR installation is complete with the exception of some injection/extraction devices and the collimators. Power testing has been underway since December 2007. Beam commissioning at the injection energy of 3 GeV is schedule for May-June, 2008. Following a summer shutdown beam acceleration commissioning is scheduled to start in December, 2008.

Comments and Recommendations

- The decision has been taken to initiate operations at 30 GeV, with 6 bunches, and a 3.0 second cycle time. This yields 100 kW of beam power at 1.2E13 protons/bunch,, which is the goal for JFY2009.

- Fast extraction kicker: The prior issue of breakdowns is being addressed with rebuilt kickers. However, the prior issue of poor risetime is not addressed in the new kicker design. As such, the new kicker design will limit operations to 6 bunches

- RF: The 5^{th} rf station must be installed to support 3.0 sec cycle at 30 GeV, and 2.0 second cycle at 30 GeV requires a 6^{th} station. Funding for the 6^{th} station is not secured

- The ATAC notes that moving from 6 to 8 bunch operations, and from 3.0 to 2.0 second cycle time, provides a factor of two in beam power.

  Recommendation: **Develop and install a kicker with a risetime sufficient to support eight bunch operation as a high priority item.**

  Recommendation: Provide adequate resources for the sixth rf system.

- Issues with ceramic coated coils on the fast extraction septa are requiring rebuilds of the magnets. However, the fast extraction system (kickers and septa) is not required for the May beam commissioning.

  Readiness of the extraction system pulsed devices remains a risk for being ready for the 30 GeV (December) commissioning run.

- Higher harmonic distortions on the power grid due to the operation of the MR power supplies are identified as an issue. The harmonic filter commissioning is scheduled to start the week of March 3 and the hope is that this will resolve this issue. It is noted that this is an issue at 30 GeV, not 3 GeV, and so will not affect the May commissioning schedule.

  Minimization of harmonic distortions on the power grid represents a potential risk item for the 30 GeV (December) commissioning run.

- Spares: The staff stated that they have essentially no spares as they enter the operations period. A general recommendation on spares is included in the section "Transition to Operations/Power Projections".

- The ATAC remains concerned about losses. Simulations presented to the committee have concentrated on initial operations at 100 kW. Losses appear acceptable at this power level,

~220 W, but extrapolation to higher powers appears to provide little margin with respect to the loss limit of 400 W.

- Machine impedance/beam instability looks like it could be a limiting issue (in MR and RCS) for operations at several × 100 kW.

  Recommendation: Continue instability analysis, utilizing existing multi-particle simulation tools (ORBIT), to estimate instability thresholds under realistic conditions.

  Recommendation: Develop a transverse damper.

  Recommendation: **Investigate whether chromaticity is effective for beam stabilization, and is consistent with the required dynamic aperture and slow extraction requirements.**

- Investigation of space-charge effects during slow extraction were presented as requested by the ATAC. It is demonstrated that slow extraction efficiency is not affected by space charge. The ATAC notes that the slow extraction is prone to potential instability during the debunching process.

  Recommendation: Investigate instability issues through the entire slow extraction process.

- The J-PARC staff have established an operational goal of 100 kW for the beam power in JFY2009. No specific plan was presented for moving beyond this in subsequent years. The ATAC believe it is important to prepare to move well beyond 100 kW in the years before the linac upgrade is completed

  Recommendation: **Establish a multi-year strategy for achievement of 400 kW performance in the MR with the 181 MeV linac, based on the April 2009 configuration as a starting point. Such a strategy could include any or all of the following: 8 bunch operations, reduced cycle time, second harmonic operations of the MR rf system, increasing the loss budget at 3 GeV, h=18 operations of the MR, h=1 operations of the RCS, and/or means for providing longer bunches from the RCS.**

RCS & MR RF System

Currently 10 stations are installed in the RCS and 4 stations in the MR. The RCS stations are performing well and have accumulated roughly 500 hours of operations. The RCS stations utilize un-cut cores, with external inductors. The MR stations utilize cut cores. This is per the plan developed a year ago.

Comments and Recommendations

- At least 11 stations will be required in the RCS to support 0.1 MW operations and beyond.
- At least 6 stations will be required in the MR to support a 2.0 second cycle time at 30 GeV.

  Recommendation: The Committee supports the requests of the RF team for additional fundamental harmonic RF systems for the RCS (1 for test and 1 for the ring in 2010) and the MR (1 for test in 2008, 1 for the ring in 2010 and 1 in 2011).

  Recommendation: The decision to build second harmonics systems for the MR shall wait until their need is clearly demonstrated by machine studies.

- It has been found that more voltage than anticipated is required to accelerate the RCS beam without loss. As a result cavities are being operated at higher gradients than the ATAC had suggested. (ATAC suggested running with limited field (85% of design) in RCS. Current operation is close to 100%.) It is important to understand why the voltage seen by beam seems low.

  Recommendation: The reason for the discrepancy between the estimated voltage and the voltage seen by the beam remains to be found. If this results from a real lack of voltage from each cavity, the construction of an additional RF system will be necessary.

- The ATAC remains concerned about long term performance of the RCS and MR RF systems. Only ~500 hours have been accumulated on the RCS stations operationally, and the Committee is concerned that there is no monitoring for any incipient degradations.

  Recommendation: The Committee suggest development of a strategy for regular monitoring of the characteristics of the cavities to provide early detection of eventual degradation of the cores. Multiple parameters can be checked, including water temperature, pollution of the cooling water with oxidation products, and systematic impedance measurement during shutdowns.

- The ATAC has supported investigation of oil filled cavities as a long term solution, particularly for the MR. Design work has been initiated

  Recommendation: Strengthen the effort invested in the study of oil cooling with the goal of a full scale demonstration on an MR cavity within 2-3 years.

- The ATAC reiterates the need for having an RCS and MR type rf systems available outside of the rings to pursue testing and development.

Transition to Operations/Power Projections
The J-PARC Phase 1 construction project is officially completed at the end of JFY2008 (March 31, 2009). An integrated plan has been prepared by the J-PARC staff establishing the commissioning and operations schedule through JFY2009.

Comments and Recommendations

- It is important to realize the full potential of the investment in the J-PARC complex.

- The long term plan as stated shows the RCS performance rising to 0.6 MW in 2013, prior to the linac energy upgrade, and to 1.0 MW following the linac upgrade. The MR beam power goal is established at 30-50% of RCS power. Over this period MR performance will not remain competitive on a world scale, nor does it represent the full potential of the J-PARC facility. The most effective approach to realizing the full capability of the J-PARC complex is by raising the energy of the linac to 400 MeV.

  Recommendation: The ATAC continues to urge the identification of funding for restoration of the linac energy to 400 MeV as a high priority item.

- A more detailed plan has been created through JFY2009. The plan establishes a goal of 280 kW from the RCS and 100 kW from the MR in JFY2009.

  Recommendation: Develop a strategy to raise the power available to 600 kW in the RCS, and 400 kW in the MR, prior to the linac upgrade.

- Following a recommendation from the ATAC the J-PARC linac team presented a table comparing design goals, commissioning goals, and current achievement. The committee views this table as responsive to our recommendation and would like to see it extended to other systems (a similar table for the RCS was prepared upon our request).

  Recommendation: Extend and maintain tables of major beam parameters containing Phase 1 design goals, commissioning goals, and currently achieved performance for each section of the accelerator complex, and use such tables to coordinate effort of beam dynamics modeling, beam physics studies, and diagnostics development.

- The ATAC is concerned about the availability of spare components as J-PARC enters its operational phase. Following our encouragement last year an analysis of the spare klystron requirements in the linac was presented to the committee which is viewed as a reasonable approach. However other systems have not yet been subject to similar analysis.

  Recommendation: Establish a spares strategy based on a risk analysis incorporating mean time between failure (MTBF), performance impacts of failures, fabrication/procurement lead times, costs, etc. Such a strategy should be used as a basis for establishing the spares component of the operations budget.

- Following a recommendation from last year a commissioning team leader has been appointed with responsibility and authority for coordinating the commissioning of the entire J-PARC complex, including the transition to operations. Progress towards an integrated commissioning/operations plan has been made with a modest level of detail through JFY2009. This plan needs to be fleshed out, extended into the future, and shared with the user community.

Recommendation: The integrated commissioning/operations plan should be extended through the first few years of operations and should be discussed with, and made available to, the user community. The published plan should include estimates of performance, anticipated reliabilities, and the time allocation between users and accelerator physics.

- Machine impedance/beam instability looks like it could be a limiting issue in the RCS and MR as operations move to a few x 100 kW.

Refer to above recommendations on RCS and MR.

- The ATAC remains concerned with the role of losses and their mitigation as a potentially limiting issue in the RCS and MR as operations move to a few x 100 kW.

Recommendation: Continue the analysis of existing and potential "hot spots" and performance bottlenecks across the whole accelerator complex. Develop back-up plans on such areas, for example the RCS collimation area, collimation area of the RCS-to-MR transport line, and possible complications associated with injection bump and extraction kicker failures.

- As first operation of the complete facility approaches, uniform operational protocols and user interfaces in the control room will become increasingly important to reduce the chance of error and the cost of operation and maintenance. For example, every effort should be made to provide tools that facilitate correlation of live and archived data from all parts of the complex.

- The J-PARC team stated that the performance level of the complex with the hardware installed at the completion of the project on April 1, 2009 will be 300 kW in the RCS and 100 kW in the MR. These performance levels leave substantial room for improvement based on subsequent investment that is modest compared to the initial investment in the facility. As stated above the committee believes a reasonable goal would be 600 kW in the RCS and 400 kW in the MR, prior to the linac energy upgrade.

Recommendation: The committee recommends that sufficient funds be set aside within the J-PARC operating budget to support modest improvements to the J-PARC complex with a goal to providing 600 kW from the RCS and 400 kW from the MR prior to the linac energy upgrade.

LINAC STATUS

The Committee was impressed with the great progress on the Linac commissioning with beam transported to the RCS and accelerated to 3 GeV. The demonstration of a 30 mA, 50 µs, and 1 Hz, beam pulse at the end of the RFQ shows the Linac is operating well and will support the initial goals of J-PARC. The demonstration of 26 mA, 50 µs, 2.5 Hz, and 181 MeV at the end of the linac shows good progress toward the 30 mA goal. Single shot operation was used extensively in the commissioning of the RCS. The Linac demonstrated very good stability and provided the required beam for the preliminary commissioning of the RCS. The Ion Source appears to be working well enough to meet the 30 mA goal. Further development of the source and RFQ will be required to meet the goal of 50 mA required for 1 MW of beam power at 3 GeV.

Linac operation, at the current intensity, is now licensed following a satisfactory government inspection.

The J-PARC staff have completed an analysis of spare klystrons needed for full operation of the linac. The 3 spare klystrons currently in the inventory may not be sufficient once full operation begins. The Linac requires 20 klystrons to operate and the expectation is that 2 or 3 klystrons may fail during a normal operating year with the possibility of even more during the first year. Recommendation: **Bring the spares inventory up to ~5 as soon as possible, and negotiate a long-term agreement with Toshiba to maintain inventory at this level.**

The beam in the linac has been very well characterized with the present beam diagnostics. The beam profiles measured after the SDTL have some halo especially the vertical profile which is not understood. Beam halo such as measured is usually caused by a transverse mismatch but can sometimes be cause by tails in the longitudinal distribution. Since the beam appears to be well matched though the SDTL, the most likely source of a mismatch that could cause this halo is in the MEBT. Since the linac has no longitudinal profile diagnostics, the bunch length can only be inferred from the energy spread measurements.
The ATAC feels the lack of bunch length monitoring within the linac needs to be rectified.

Ion Source

The ion source that was selected uses a LaB6 filament to increase the source life time and increase the ion current. This source can operate at the beam current and duty factor required for the J-PARC #1 stage. The new hybrid arc power supply has stabilized the arc current and solved the stability problem and the pulse current sag for the 600 µs beam pulse.

Pre-chopper and chopper

The pre-chopper and ion source have been installed in a shielded enclosure but the pre-chopper has not been used for linac commissioning runs and is no longer planed to be used. The RF chopper tests show the Graphite target can withstand a beam of 25 mA, pulsed at 25Hz and 50 µsec with chopping ratio of 100%. However, this only tested the chopping target to only ~20% of power level needed for the full 30mA beam current pulsed 25Hz with a 500 µsec pulse length and 50% chopping ratio. Further testing of the RF copper needs to be done. The idea of using a

RF chopper at half the 324 MHz frequency that will spread the beam load onto two targets should be pursued.

Linac Upgrade Plan

The linac upgrade plan is to install an ACS accelerator to increase the energy of the linac to 400 MeV. This upgrade is necessary to reach the design power of 1 MW at 3.0 GeV. To implement this plan, two ACS buncher modules have been fabricated and tested under power and one low beta accelerating module has been fabricated and characterized at low power. The low beta module exhibits a tilt in the accelerating fields when the tuner is inserted enough to tune the module to the required frequency (972 MHz). Even though this tilt is undesirable the module is probably usable as is. However, there may not be enough vacuum pumping on the module. There are vacuum pumps on both ends of the relatively long module and a small pump near the waveguide window. The concern is the vacuum conductance of the structure may not be enough to RF condition the cavity in a reasonable time. (Evidence: 12 hours to get up to full power on the buncher which is significantly shorter than the accelerating modules.

Another concern is that it is impossible to tune accelerating cavities in the ACS after brazing. In the Low Beta module, both the accelerating and coupling cavities have a resonate frequency that is higher than they should be. The coupling cavities average frequencies in the two tanks of the module are 0.78 and 0.48 MHz higher than the operating frequency respectively. The average frequencies of the accelerating cavities in the two tanks are about 0.2 MHz high. It is probably impossible to lower the frequency of the coupling cavities after brazing the structure. This tuning results in a stop band in the dispersion curve. When the tuner in the bridge coupler is used to lower the accelerating mode frequency to 972 MHz, the perturbation from the tuner and the stop band results in a tilt in the fields. The tilt will be proportional to the perturbation from the tuner which explains why there is very little tilt when the movable tuner is at the inner limit and large tilt when the tuner is at the outer limit where frequency of the accelerating mode has been lowered below the normal operating frequency.
When the tuner is at the outer limit and the field tilt is excessive, the excitation of coupling cavities is increased. Because, the Q of the coupling cavities is lower than the accelerating cavities, the Q of the accelerating mode is reduced compared to the case where the tuner is at the inner limit and the tilt is small.

During the tuning of the structure, before the tank is brazed, the frequencies of the individual accelerating cavities and coupling cavities are measured in a stack of 34 disks. After these measurements the cavities may be tuned by additional machining of the individual cavities. The frequencies of the individual cavities formed by a pair of disks may also be measured, but there is always some offset in this measurement compared to the measurement in the stack. This offset should be consistent and depending on the boundary conditions and the second neighbor coupling, the offset may be quite large, or very small. For example, the accelerating cell frequency of a half accelerating cell should be very close to the frequency of the full cell because of the mirror symmetry of the coupling slots in the accelerating cell. However, the coupling cavity frequency should always be measured with a pair of disks because the coupling cavities do not have mirror symmetry.

There is always some uncertainty in the frequency of the cavities measured before brazing because of imperfections in the matting surfaces. But care should be exercised in controlling or measuring the effect of the environment. For example, the cavities should be purged with dry nitrogen to remove the uncertainty of the humidity in the air on the measured frequency. The effect of the nitrogen on the frequency is nearly constant because the atmospheric pressure is relatively constant. In addition, if the cavity is to have a resonate frequency of 972 under vacuum at 20ºC , the measured frequency in dry nitrogen is 971.703±0.01 MHz for a ±25mmHg variation in atmospheric pressure with the cavity at 22ºC. If the same measurement is made in air with relative humidity of 50%, the frequency would be 971.653. The total effect of humidity changing from 0% to 100% is about -0.11 MHz with the highest humidity lowering the frequency the most.

Recommend:

> **Establish specifications for the measurements of frequency in the stack assembly prior to brazing that will result in a structure with the accelerating and coupling cavity frequencies within specifications.**
>
> Think about implementing a method of fine-tuning the coupling cavities after the module is brazed.

Klystrons.

The 972 MHz Klystron under development, with three units produced and tested, all have stability problems.

ATAC feels that modulating the output of the klystrons at 1.2 MHz to compensate for beam loading at the chopping frequency may not be such a good idea. (Danger is exciting a nearby mode in the accelerating structure.) The observed instability is possibly related to large bandwidth required for the 1.2 MHz modulation.

> Recommend: **Reevaluate whether 1.2 MHz modulation is really needed.**

The ATAC suggests reconsideration of the type of accelerating structure, including superconducting or side coupled, for the energy upgrade if funding is delayed by a year or two

The ATAC is convinced that the full potential of the J-PARC complex cannot be realized with a 181 MeV linac.

Recommendation: **The ATAC continues to urge the identification of funding for restoration of the linac energy to 400 MeV as a high priority item.**

3 GeV Rapid Cycling Synchrotron Status & Commissioning Plan

The 3 GeV Rapid Cycling Synchrotron(RCS) is located in a 348 m long tunnel and will provide proton beam to a high power neutron spallation target as well as to the 50 GeV Main Ring (MR). With a beam intensity of 8.3×10^{13} protons per cycle, a repetition rate of 25 Hz and an injection energy of 400 MeV, the RCS can deliver 1 MW beam power at the 3 GeV extraction energy. The lower injection energy of 181 MeV, which is part of the present Phase I construction project, reduces the beam power of the RCS to .33 to .6 MW ($2.6\text{-}4.8\times10^{13}$ protons per cycle). At the upper end of this range the beam loss is likely to exceed beam loss limits in the RCS and in the transport lines to the neutron spallation target and the Main Ring.

Since the last ATAC meeting the construction of the RCS was completed and first beam was injected and then accelerated and extracted in record time and significantly ahead of schedule. During the commissioning effort a beam power of 52 kW was delivered to the 3 GeV beam dump for a short time.

Note that findings, comments and recommendations with regard to the RCS rf system are included in the separate rf section.

Comments and Recommendations

- In the RCS five transverse collimator systems are being installed to capture halo particles. Each collimator jaw is capable of absorbing 0.4 kW beam power in the vertical plane and 0.7 kW in the horizontal plane. The total design beam loss on all collimators is 4 kW. The committee still thinks that it is likely that under operational conditions, with 36 kW of beam power from the 181 MeV linac, the heat load on an individual collimator jaw will exceed the specification. During the present commissioning runs the loss distribution on the RCS collimator should be carefully investigated and should be compared with model calculations. In addition, the design of a new collimation system for the RCS with improved cooling and shielding should start as soon as possible.

  Recommendation: Prepare an improvement plan for the RCS collimator system to provide sufficient margin to cope with realistic operations scenarios.

- Measurements of the longitudinal and transverse impedance of the RCS extraction kicker system that included the powering cable and the pulse forming network agree reasonably well with calculations and show values for the transverse impedance of up to 10^5 Ohms/m, mainly due to reflections in the cable. This is significantly above the calculated instability threshold. Possible schemes to suppress the reflections were discussed. It is difficult to accurately predict whether this impedance will actually lead to instabilities in the RCS. However, contingency plans for this possibility should be developed as soon as possible, which could include the construction of a transverse damper and/or a redesign of the RCS extraction kicker.

  Recommendation: Prepare plans to address beam instabilities caused by the large kicker impedance.

- The design flatness of 1% for the RCS extraction kicker pulse was then achieved by miss-timing individual modules at the expense of increasing the kicker rise time from about 250 ns to about 360 ns. This rise time is slightly bigger than the bunch gap of 350 ns. The project should evaluate the beam loss associated with the increased kicker rise time.

  Recommendation: Perform tests with beam whether the RCS kicker rise time is sufficient for full power operation.

- An improved multiple particle tracking calculation with space charge was presented that includes the multi-pole components and field and alignment errors of the dipoles, quadrupoles, and sextupoles, and the measured power supply tracking errors. These calculations include longitudinal injection painting and the proper evolution of the RF bunch shape throughout the acceleration cycle. For 0.3MW operation the losses were less than 1 kW. For the 0.6MW operation the losses exceeded the collimator limit of 4 kW.

  Recommendation: Continue to utilize the integrated tracking simulations as an aid to evaluating the loss budget.

- The extraction kickers have been installed without coating the Ferrite and aluminum surfaces with TiN. These surfaces have large Secondary Electron Yield (SEY) coefficients, which can only be improved by coating them. Although it is not practical to coat these surfaces at this time preparations should be made to coat the kicker surfaces in the future.

  Recommendation: Prepare for coating the Ferrite and aluminum surfaces of the extraction kicker. Coating with TiN was successfully achieved for the SNS project.

- The commissioning of the RCS was very successful and proceeded very quickly. The effort made good use of the “single shot” capability to limit beam component activation. The availability of instrumentation and high level application software to support the commissioning effort on day one was outstanding. The closed orbit deviations at injection without any correction were quite small and were easily corrected. Most linear lattice parameters were measured and successfully corrected.

- The most significant error sources came from the non-linear leakage fields of the beam septa. Without correction the beam did not survive in the machine. Even with correction of the closed orbit and chromaticity a 5% beam loss remained. The non-linear leakage fields should be corrected locally with either magnetic shielding or correction coils.

  Recommendation: Implement local correction of the leakage fields of the RCS septa.

- The rf by-pass capacitors of the copper strips on the ceramic beam pipes of the injection orbit bump dipoles arced and had to be removed to continue RCS commissioning. The cause for this failure should be identified and a permanent solution should be developed.

The fast rise time of these magnets makes it difficult to choose an appropriate capacitance value. Alternative solutions such as thin metallic coating of the ceramic vacuum chambers should be investigated.

Recommendation: Develop a permanent solution for the wall current conduction in the injection orbit bump dipoles.

- During commissioning a beam loss of 6% was measured with 4.6e12 protons in a single bunch. The loss occurred during the first1.5 ms of the acceleration ramp and no longitudinal or transverse painting was used. With both buckets filled and at 25 Hz this would correspond to 110 kW beam power at 3 GeV and the lost beam power would be about 400W. By simulating the conditions of this measurement as well as testing beam injection with transverse and longitudinal painting, scaling to full operating current and beam power should determined. If painting increases the beam emittance proportionately to the intensity linear scaling could be expected. In this case, at the output power of 600 kW, the lost beam power would be 2.2 kW. This would still be below the 4 kW limit for the collimators but would exceed the limit of a single collimator jaw.

Recommendation: Continue the commissioning studies with injection painting to explore high intensity operation.

50 GeV Main Ring Synchrotron Status & Commissioning Plan

Findings:

The committee was pleased to observe first hand that installation of almost all of the main ring components is complete, with the exception of collimators and some injection and extraction system equipment. The J-PARC team is to be congratulated on this significant accomplishment.

The first stage of beam commissioning, including beam injection, COD correction and RF capture is scheduled for May and June of 2008. For this first stage, two bunches (4.2×10^{11} ppb) of 3 GeV protons yielding a power of 120 W will be injected into the Main Ring and extracted to the 3 GeV injection beam dump. This can be accomplished using the four RF cavity systems already in place. A fifth cavity is required and will be installed before the second stage of beam commissioning, scheduled from Dec. 2008 to Feb. 2009, when beam acceleration to 30 GeV, fast beam extraction to the beam abort line and slow beam extraction to the hadron beam line at a power of 1.2 kW is planned. A third commissioning stage is scheduled from April to June in 2009. At that time beam power will be increased to 3.6 kW with six bunches (still at 4.2×10^{11} ppb) at a three second cycle time guided to the neutrino beamline dump after fast extraction. A decision has been taken that initial operation to both hadron and neutrino beam lines in September of 2009 will be at 30 GeV with six bunches and a three second cycle time yielding 100 kW of beam at an intensity of 1.2×10^{13} ppb.

A detailed commissioning plan and schedule for each of these phases was presented to the committee.

Comments and Recommendations:

The committee feels that 100kW of beam power is an unduly modest goal that severely under exploits the potential of the J-PARC facility and that it is important to prepare to move well beyond 100 kW in the years before the linac upgrade is completed.

Recommendation:

Establish a multi-year strategy for achievement of 450 kW performance in the MR with the 181 MeV linac, based on the April 2009 configuration as a starting point. Such a strategy could include any or all of the following: 8 bunch operation, reduced cycle time, second harmonic operation of the MR rf system, increasing the loss budget at 3 GeV, h=18 operation of the MR, h=1 operation of the RCS, and/or means for providing longer bunches from the RCS. Simply increasing the number of bunches from 6 to 8 and reducing the cycle time from 3 seconds to 2 would result in an improvement in beam power of a factor of two.

Fast Kicker: Previously reported extraction kicker instabilities have been successfully addressed by modifying the kicker to a lumped constant type replacing the traveling wave type.

The new kicker has demonstrated stable operation; however its rise time of ~2μsec is even longer than the original traveling wave version, thereby limiting operation to 6 bunches rather than 8.

Recommendation:

Develop and install a kicker with a risetime sufficient to support eight bunch operation as a high priority item.

RF: (A more detailed discussion of RF issues appears in a separate section below.) Long term stability of RF cavities discussed last year seems to be tolerable although further careful observation is still needed. As noted above, a fifth RF station will be installed to support a 3.0 second cycle at 30 GeV. To reach a 2.0 second cycle time, a sixth station will be required; however funding for that station has not yet been secured.

Recommendation:

Provide adequate resources for the sixth rf system.

Harmonic Distortion: Higher harmonic distortions on the power grid caused by the operation of the Main Ring power supplies has also been identified as a possible limiting factor for 30 GeV operation. It has been found that the guideline of <1% total harmonic distortion (THD) of the AC voltage may be exceeded even with a single power supply and after installation of a planned 6.5 MVar harmonic filter that will be installed and tested next week. In the event that the THD is larger than 1%, installation of additional filter systems might be needed, and these have a long delivery lead time.

Recommendation:

Provide adequate resources for any additional filter systems found to be required, and plan for a timely procurement so as not to impact commissioning at 30 GeV.

Transverse Impedance/Beam Instability: Machine impedance/beam instability could also be a power limiting factor in the RCS and MR for operation at several hundred kilowatts. Evaluations of the transverse impedances due to the kickers and the MR stainless steel chamber were reported to the committee. The growth rate of horizontal and vertical head-tail instabilities remains significant at low frequencies (around 100 to 200 Hz) even with chromaticity correction. Ceramic breaks are being installed to the beam chambers next to every bending magnet to reduce eddy current effects. RF shields for the ceramic breaks have been designed, fabricated and installed.

Recommendation:

Continue instability analysis, utilizing existing multi-particle simulation tools (ORBIT), to estimate instability thresholds under realistic conditions.

Recommendation:

Possible cure of the transverse instability should be investigated and a transverse damper developed if necessary.

Recommendation:

Investigate whether chromaticity is effective for beam stabilization, and is consistent with the required dynamic aperture and slow extraction requirements.

Fast Extraction: Issues with ceramic coils on the fast extraction septa are requiring rebuilds of the magnets. This system (kickers and septa) is not required for the May commissioning run, however readiness of the extraction system pulsed devices remains a concern for the 30 GeV beam commissioning in December 2009.

Slow Extraction: The committee heard reports on construction for slow extraction system devices including foil type electrostatic septa, sextupole magnets for resonance excitation, magnetic septa, quadrupole magnets for spill feedback and beam spill control. Investigation of space-charge effects during slow extraction were presented as requested by the ATAC. It has been demonstrated that slow extraction efficiency is not affected by space charge; however the ATAC notes that the slow extraction is prone to potential instability during the debunching process. Electron cloud effects are also anticipated and should be investigated.

Recommendation:

Investigate instability issues through the entire slow extraction process.

Recommendation:

A beam monitoring system to observe the slow extraction process is required to enable the orbit and beam control during the extraction process.

Losses: The ATAC Committee remains concerned about losses. Simulations indicate that losses are at 330 W when operating at 200kW, whereas the specified loss limit is 400 W.

Recommendation:

Continue to improve understanding of losses throughout the facility by pursuing integrated simulation studies that include realistic injection beam parameters, consistent voltage profiles, space charge effects and errors.

***Spares*:** The overall issue of adequate spares is discussed below. As is the case elsewhere in the complex, the MR staff reported essentially no spares.

Ground Motion: During the process of magnet alignment ,local changes in vertical position were observed at some positions around the MR.

Recommendation:

To avoid unexpected beam loss due to ground motion, careful observations should be continued, especially where a large local deviations have already been observed.

RCS & MR RF Systems

In the J-PARC synchrotrons, Magnetic Alloy (MA) disk-loaded cavities are being used for the first time in a large size accelerator facility. This new type of cavity has significant advantages with respect to conventional ferrite-loaded devices, for example the larger accelerating gradient that can be obtained at low frequencies and the absence of tuning system. A number of technological difficulties were encountered during their development and the beginning of series construction. These were the subjects of intense work by the J-PARC/KEK RF team during the past years, and progress and alternatives have been reviewed in detail during the previous ATAC meetings, especially in 2006 and 2007. The successful construction and operation of the 10 RF systems of the RCS is a remarkable result for which the Committee is glad to congratulate all contributors.

Findings

RCS RF systems

The 10 RCS cavities are equipped with uncut cores and an external inductor in parallel with the resonator to increase the quality factor up to ~2. This innovative solution eases fabrication and avoids the problems associated with cutting the cores.
To reduce heating and minimize residual corrosion mechanisms the voltage in the cavities was foreseen to be limited to ~ 40 kV (45 kV nominal). *It has unfortunately been observed during beam commissioning that the voltage experienced by the beam is smaller than expected and required for lossless acceleration. The net result is that the 10 RF systems installed in the RCS have to operate at nominal voltage.*

The anode power supplies had a couple of failures due to water leaks from faulty weldings on the cooling pipes. All units will be repaired before this summer.

Some gap capacitors could not withstand the nominal voltage. They have therefore been systematically checked and all cavities are now equipped with capacitors which have successfully passed the tests.

RCS LLRF

The LLRF provides control of the amplitude and phase of the cavity voltages and it is able to compensate beam-loading on two harmonics simultaneously. The beam phase and radial loops have not been used for the time-being. *The quality and reproducibility of beam acceleration in open loop demonstrates the quality of the frequency programme and the cleanliness of the RF synthesizer.*

MR RF systems

In the case of the MR cavities, with an optimal quality factor of 26, the technique used in the RCS is not sufficient and cut cores are required. Therefore the 5 MR cavities that have been built are equipped with cut cores obtained by water-jet cutting followed by diamond polishing of the cut part. Low oxygen-content water must be used as the cooling fluid to minimize corrosion. Four cavities have already been installed in the ring, and one has been kept outside for test. For the first attempts at acceleration in the MR, in December 2008, all five systems will be needed in the ring, and tests will have to stop. *An additional RF system is therefore necessary to keep the possibility to continue testing and improving.*

Inventory of RF systems

At the end of 2008, without any new construction, the RCS will be equipped with 11 RF systems and the MR with 5. No equivalent system will be available outside. *For a safe operation of the RCS, the request is made to build two additional systems, the first one for test purposes in 2009 and the second in 2010 for installation in the ring. For the MR, the proposal is to make a 6th fundamental harmonic RF system available for test at the end of 2008, and to build two additional systems for installation in the ring in 2010 and 2011. The first second harmonic RF system is requested in 2010 and the second one in 2011.*

Oil-cooled MA cavity

A work program has been launched to study the possibility to use paraffin instead of water as the cooling fluid. The on-going work is aimed at the MR cavity because of the cut cores. The cooling performance of a spiral flow of the paraffin around the edge of the cores has been studied. The electromagnetic and thermal calculations show that this solution is feasible when assuming a mean power dissipation of 12 kW/core (maximum oil temperature: 54 deg.C for a flow rate of 1m/s). *An experimental set-up is in construction to check the validity of the solution during the first quarter of FY08. A specific core fabrication technique is under investigation.*

Comments & recommendations

The ATAC congratulates the J-PARC RF team for the remarkable success in the use of MA-loaded cavities in a large size and high performance accelerator.

The solution selected for the RCS is original and allows for using uncut cores while providing adequate RF performance for full beam power. The Committee is however concerned with the discrepancy observed between the estimated voltage and the voltage experienced by the beam.
Recommendation: the reason for the discrepancy between the estimated voltage and the voltage seen by the beam remains to be found. If this results from a real lack of voltage from each cavity, the construction of an additional RF system will be necessary.

Because of this apparent lack of voltage, the RCS cavities have to operate at the nominal voltage, without safety margin.
Recommendation: monitoring regularly the characteristics of the cavities is important to reveal early an eventual start of degradation of the cores. Multiple parameters can be checked, like water temperature to detect an increase in dissipation, pollution of the cooling water to detect oxidation products and systematic impedance measurement during shutdowns…

All existing MR RF systems will be installed in the ring in December 2008. If no additional system is assembled, it will become impossible to continue testing.

Recommendation: It has not yet been demonstrated that MR cavities can operate over a multi-year time span. It is essential to keep a test system operating to pursue analysis and development.

The number of RF systems which will be installed in both rings at the end of 2008 is marginal, especially considering the need to operate them ~10 % below their nominal gradient. No spares will exist, and no system will be left available for test outside of the rings.
Recommendation: The Committee supports the requests of the RF team for additional fundamental harmonic RF systems for the RCS (1 for test in 2010 and 1 for the ring in 2011) and the MR (1 for test in 2008, 1 for the ring in 2010 and 1 in 2011). The decision to build second harmonics systems for the MR shall wait until their need is clearly demonstrated by machine studies.

Experience is still missing on the long term evolution of Finemet-loaded cavities in operational conditions and high RF power. Therefore the ATAC confirms his support to the study of oil-cooling as a potential alternative solution in the long term.
Recommendation: strengthen the effort invested in the study of oil-cooling with the goal of a full scale demonstration on an MR cavity within 2 to 3 years. The links between the scientists in charge of this development and the J-PARC RF team have to be tightened to make sure that adequate operating assumptions are used and that the demonstration system will be operationally viable.

Transition to Operations/Power Projections

Since the last A-TAC review construction of accelerator equipment and facilities proceeded on schedule. The beam was successfully accelerated in the RCS to 3 GeV and extracted. A total of 9 linac and 5 RCS beam commissioning runs were conducted each lasting for 12 days. Hardware commissioning is in progress in the MR. The linac beam peak current reached 25 mA (30 mA by present design) when the beam repetition rate is 2.5 Hz (25 Hz by design), and when the pulse length is 50 us (500 us by design). The RCS operated without injection painting in either single-shot or 1 Hz repetition-rate (25 Hz by design) mode with 1-bunch (2-bunch by design) reaching an intensity of 4.4×10^{12} protons per bunch about, i.e. about 10% of the design intensity.

Beam commissioning of the MR is planned in 3 stages with 2-month, 3-month, and 3-month duration, respectively, starting in May 2008. Two cycles of neutron experiments and a cycle of hadron experiments are scheduled in Japanese Fiscal Year 2008.

In the absence of a linac energy recovery to 400 MeV, the J-PARC team projected reaching RCS beam power of 300 kW around mid JFY2011, and 600 kW around the end of JFY2013. Presently, stage-1 of linac recovery has been approved with a budget of 1.5 Oku Yen supporting one year of R&D. If stage-2 of linac recovery (estimated at a four-year budget of about 90 Oku Yen) is approved to start immediately after the completion of project phase-I, the team projected reaching beam power of 1 MW around the end of JFY2013.

Comments and recommendations

- The linac energy recovery plan takes more than 4 years of R&D preparation, component fabrication, and system integration. We recommend continued funding to support the plan immediately following the current stage-1 efforts.

  Recommendation: The ATAC continues to urge the identification of funding for restoration of the linac energy to 400 MeV as a high priority item.

- The committee is encouraged that a leader is identified to coordinate the overall accelerator commissioning. The committee believes that reaching the projected beam power goal with 600 kW in the RCS and 450 kW in the MR with the 181-MeV linac requires significant amount of commissioning planning, budget and personnel resource support, and decisive execution.

  Recommendation: Develop a strategy to raise the power available to 600 kW in the RCS, and 400 kW in the MR prior to the linac upgrade, based on commissioning progress, schedule, available budget and personnel support, and integrate with the commissioning plans.

- Tables of some major beam parameters containing phase I design goal, commissioning goal, and currently achieved performance were presented for linac and RCS. These tables should be expanded to include essential parameters like beam emitttance and controlled and uncontrolled beam losses, to cover each section of the accelerator complex including transport lines; should be updated according to the commissioning progress; and should be used to coordinate efforts of beam dynamics modeling, beam physics studies, and beam diagnostics development.

Recommendation: Extend and maintain tables of major beam parameters containing phase I design goal, commissioning goal, and currently achieved performance on each section of the accelerator complex, and use such tables to coordinate efforts of beam dynamics modeling, beam physics studies, and beam diagnostics development.

- Spares is an outstanding issue affecting commissioning progress and project cost. An analysis was presented on the linac klystron systems. The effort needs to be expended to other systems of the facility where spares are needed. As we recommended at the last review, a formal document containing performance risks, mean-time-between-failure, procurement lead time, and cost of all major components can be important both in the planning and in convincing the management agencies.

Recommendation: Establish a spares strategy based on a risk analysis incorporating mean time between failure (MTBF), performance impacts of failures, fabrication/procurement lead times, costs, etc. Such a strategy should be used as a basis for establishing the spares component of the operations budget.

- As the commissioning progresses, areas of bottlenecks limiting the performance and "hot spots" where activation level is high start to show. An example is the RCS collimation area. Potential areas include those associated with extraction kicker failures and the collimation region of the transfer line between RCS and MR. Special efforts are needed including real-case computer simulation, beam dynamics analysis, dedicated beam study and diagnostics, and back-up plan development. For example, a dedicated study may include independently adjusting each jaws of the RCS collimator to understand the distribution and timing of the beam loss under different machine conditions.

Recommendation: Continue the analysis of existing and potential "hot spots" and performance bottlenecks across the whole accelerator complex. Develop back-up plans on such areas, for example the RCS collimation area, collimation area of the RCS-to-MR transport line, and possible complications associated with injection bump and extraction kicker failures.

- The committee is encouraged that beam dynamics studies and computer simulations are performed incorporating space-charge effects and magnetic errors. The committee is also encouraged that collective effect studies are continuing. Potential problematic areas identified include effects associated with extraction kicker impedance, MR resistive wall impedance, and electron cloud. Continuous efforts need to be made and countermeasures pursued. For example, SNS studies indicated agreement between beam observations and theoretical analysis on several instabilities in the ring. Such analysis may be applied to the RCS as a reference. Continued efforts are encouraged in minimizing the impedance of the kicker systems, and on R&D of ferrite TiN coating and feedback systems.

Recommendation: Continue beam dynamics efforts on both single-particle and collective-effect analysis. Continue to develop remedies and back-up plans.

- As first operation of the complete facility approaches, uniform operational protocols and user interfaces in the control room will become increasingly important to reduce the chance of error and the cost of operation and maintenance.

Recommendation: Every effort should be made to provide tools that facilitate correlation of live and archived data from all parts of the complex.

Appendix: Meeting Agenda

ATAC2008 Agenda_final

February 28, Thursday

time		period (min)	Category	Title	Speaker	File Name
820		*Bus starts at 8:20 from the hotel to the meeting place.*				
910	930	20	**Project status**		S. Nagamiya	28a01.pdf
930	1000	30	**Accelerator Overview**		Y. Yamazaki	28a02.pdf
1000	1020	20	**Executive session**	*closed*		
<< coffee break >>		20				
1040	1100	20	**Linac**	Status of Linac	K. Hasegawa	28a03.pdf
1100	1130	30		Beam Commissioning Results for the Linac	M. Ikegami	28a04.pdf
1130	1150	20	**RCS**	Status of RCS	M. Kinsho	28a05.pdf
<< lunch >>		80	*Please walk to cafeteria. If you do not like Japanese lunch, we prepare sandwiches and coffee only for committee members.*			
1310	1350	40		Beam Commissioning Results for the RCS	H. Hotchi	28p01.pdf
1350	1440	50	**Ring RF**	Status of Ring RF	M. Nomura	28p02.pdf
				Ring RF backup scenario	J. Kameda	28p03.pdf
<< coffee break >>		20				
1500	1530	30	**Control**	Status of Control System	N. Yamamoto	28p04.pdf
1530	1645	75	**Linac energy upgrade**	R &D Status of the ACS for the Linac Energy upgrade	H. Ao	28p05.pdf
				Other technical issues	Y. Yamazaki	28p06.pdf
				Rf source	E. Chishiro	28p07.pdf
1645	1745	60	**Executive session**	*closed*		
<<RECEPTION>> 1820 - 2030 (Bus starts at 18:00 from the meeting place to the restaurant)						

February 29, Friday

time		period (min)	Category	Title	Speaker	File Name
815		*Bus starts at 8:15 from the hotel to the meeting place.*				
830	900	30	**Executive session**	*closed*		
910	940	30	**MR**	Status of MR -perspective from beam commissioning	T. Koseki	29a01.pdf
940	1020	40		Kicker of fast extraction	K. Koseki	29a02.pdf
				Septa of injection/extraction	K. Ishii	29a03.pdf
<< coffee break >>		20				
1040	1100	20		Slow extraction system	M. Tomizawa	29a04.pdf
1100	1120	20		Space charge simulation	A. Molodojentsev	29a05.pdf
1120	1140	20		Impedance and instability	Y. Chin	29a06.pdf
1140	1200	20		Alignment	M. Shirakata	29a07.pdf
<< lunch >>		70	*Please walk to cafeteria. If you do not like Japanese lunch, we prepare sandwiches and coffee only for committee members.*			
1310	1610	180	**Tour J-PARC**	RCS, MLF and MR		
1610	1740	90	**Executive session**	*closed*		
<< dinner >> 1820 - 2000 (Bus starts at 18:00 from the meeting place to the restaurant)						

March 1, Saturday

time		period (min)	Category	Title	Speaker	File Name
850		*Bus starts at 8:50 from the hotel to the meeting place.*				
900	1100	120	**Executive session**	*closed*		
1100	1200	60	**Report to project team**		S Holmes	
<< lunch >> 1220 - 1320 (Bus starts at 12:00 from the meeting place to the restaurant)						

adjourn