NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

Working Group on the Analysis and Management of Accidents

EXPLORATORY MEETING OF EXPERTS TO DEFINE AN ACTION PLAN ON BEST ESTIMATE CALCULATIONS AND UNCERTAINTY ANALYSIS

Held in Aix-en-Provence, France
13-14 May 2002
EXPLORATORY MEETING OF EXPERTS
ON BEST ESTIMATE CALCULATIONS
AND UNCERTAINTY ANALYSIS

DEFINITION OF AN ACTION PLAN

(Aix-en-Provence, France, 13-14 May 2002)

SUMMARY RECORD

I. General - Purpose of the meeting - Approach

1. Dr. Micaelli welcomed the participants – a list is given in Annex 1 - on behalf of the Institut de Radioprotection et de Sûreté Nucléaire (IRSN). He reminded the participants that the purpose of the meeting was to develop an Action Plan on Best Estimate calculations and uncertainty analysis. This would require to better identify the needs for additional investigations in this field, with a view to reaching technical consensus on understanding and methodologies, and to making progress in the Best Estimate analysis of Design Basis Accidents and Severe Accidents. The meeting was open to organisations interested in participating in the definition of this programme

2. The following approach had been suggested by Dr. Micaelli to GAMA, who had endorsed it:
   - With respect to methodologies already used in safety analysis:
     - Identify weak points (difficulties regarding implementation, justification of basic assumptions, etc.); this task would require the participation of experts having experience in safety analyses.
     - Identify questions of general interest (weak points not too specific to a particular methodology).
     - Perform an inventory and analysis of actions underway to solve the problems.
     - Propose complementary or supporting actions to make progress together.
   - With respect to methodologies not yet used in safety analysis:
     - Identify the issues to be solved, in order to convince end users to make use of the methodology.
     - Perform an inventory and analysis of actions underway to solve the problems.
     - Evaluate how much time could be necessary to solve the problem (short term, medium term, long term).
     - Propose actions to make common progress on the most promising alternative methods.

3. The following actions could be considered, among others:
   - Examine methodologies used in other fields (weather forecast, etc.).
   - Develop tools and methods (quantification of basic uncertainties, treatment, etc.).
   - Develop/improve the validation methodology of uncertainty evaluation methods.

1 Including participants’ comments on an earlier draft version.
• Define a consistent programme of computational benchmark exercises (based on SET and/or IET and/or reactor scenarios) associated to the specification of clear procedures allowing an actual evaluation and comparison of the methodology.

II. First session: Use and/or analysis of Best Estimate methodologies by end-users

[Chairman: Prof. F. D’Auria, University of Pisa]

4. This session consisted of presentations by end-users (utilities and/or safety organisations). It covered already applied or proposed methodologies. The general objectives were:

• to identify difficulties regarding practical use, justification of basic assumptions, etc.,
• to identify improvements wished by end-users, and
• to identify general interest questions (as far as possible, weak points not too specific to a particular methodology).

5. The first paper, presented by Mrs. Cadet-Mercier, was entitled “LB LOCA Best-Estimate Methodology”. It recalled the fundamental points of the large break LOCA evaluation method, presented the EDF methodology (its principles, the application of the ‘Deterministic Realistic Method’ to LB LOCA, the main features of the CATHARE GB code, and the key points of the PCT95 evaluation and PCT DRM), and described the Best Estimate methodology feedback. The conclusion of this work was that improvement was needed in the determination of uncertainty ranges and in the propagation methodology. The global impact of all parameters had not been considered.

6. The second paper, entitled “The Tractebel Deterministic Bounding Approach to Accident Analysis”, was presented by Dr. Jinzhao Zhang. The following topics were discussed: choice of codes, qualification of codes, building of standard plant model, establishment of accident analysis methodology, application to licensing accident analysis. The paper concluded that the Tractebel deterministic bounding approach

• used Best Estimate codes for more precise simulation of the key physical phenomena,
• was based on engineering judgements rather than on rigorous statistical treatment of the uncertainties and conservatisms,
• kept the same uncertainties and conservatisms as in the initial Design Basis Accident analysis,
• was consistent with the current licensing basis and hence easily acceptable by the Safety Authorities,
• was cost-effective for applications.

However, the method

• needed a large number of sensitivity studies for methodology establishment,
• needed a high level of expertise for development and application,
• might involve certain non-quantified margins due to simplistic and decoupled enveloping assumptions.

7. In the future, use would be made of coupled system thermal-hydraulics, sub-channel core thermal-hydraulics and 3-D neutronics codes and methods to avoid unnecessary penalties due to incoherent approximations in the traditional decoupled method, and of more realistic and suitably
conservative assumptions to obtain more accurate evaluation of margins with respect to the licensing limit.

8. The presentation made by Dr. Kasahara was entitled “Experiences of TRAC-P Code at INS/NUPEC”. It was divided into three parts:
   - preparation of the input data with a fine noding model,
   - large break LOCA analysis using a fine noding model,
   - uncertainty methods study by a coarse noding model.

The paper concluded that a prototype GRS-type uncertainty evaluation system had been developed. Future work would consist in the selection of several ten pieces of cause parameters, the modification of the TRAC-P code to handle those parameters by “tracin”, and the application of this uncertainty evaluation system to the evaluation of three peaks of large break LOCA PCT using a fine noding model.

9. Dr. Macian presented a paper on “Best Estimate Analysis Methodology in the STARS Project at PSI”. The Project performed Best Estimate deterministic safety assessment of the Swiss nuclear power plants on behalf of the Swiss nuclear safety authority (HSK) and the utilities. The overall goal was to provide independent expertise in deterministic safety analysis to HSK and the utilities:
   - identification and quantification of safety margins in existing Swiss nuclear power plants,
   - technical input for safety related decisions based on timely and independent analysis.

Dr. Macian described the tools and the philosophy of Best Estimate analysis in the STARS Project, the code development model and its assessment, code assessment and code applications. PSI had concluded that Best Estimate codes should be able to handle a wide variety of different transients, operational or unanticipated, in a numerically robust way, with a minimum of manipulation of qualified plant models. Validation and assessment of the adequacy of code models for the intended application was essential to justify the results of any Best Estimate analysis. This could be helped by:
   - easy access to relevant experimental data: a central, extensive data base (Separate Effects and Integral Test data) would help substantially;
   - easy access to plant data: these are essential for qualifying plant and code models;
   - assessment against experimental data, as it provides very valuable information for uncertainty methodologies.

Finally, Dr. Macian said that the application of uncertainty analysis to Best Estimate results was becoming important for decision-making, e.g. licensing, plant operation and configuration changes, etc.

10. Dr. Glaeser presented a paper entitled “Experience in Application of Uncertainty Methods, Participation in Uncertainty Methods Study and Review of Methods Used in Licensing”. The paper covered the following topics:
   - application of uncertainty evaluation methods in Germany,
   - conclusions of the “Uncertainty Methods Study”,
   - short overview on the international situation in licensing,
   - further support development in GRS, future co-operation with FZK.

11. The following conclusions had been drawn from the performed uncertainty analyses:
• there were high requirements in determining uncertain input parameters:
  • selection of suitable experimental and analytical information to determine ranges and probability distributions,
  • transfer of measured data into these ranges and distributions,
  • determination of ranges of calculation results were recommended for codes developed at GRS and important accident scenarios,
  • uncertainty importance ranking guides were leading to improvement of knowledge and effective code improvements.

12. Recommendations had also been made with respect to the Uncertainty Method Study (UMS):
  • collection, qualification, review and dissemination of uncertainty data should be made more systematic,
  • code manuals should include relevant uncertainty information,
  • more efforts should be made to transform data measured in experiments and compared with post-test calculations into model parameters with uncertainties,
  • uncertainty analysis should be performed if useful conclusions are to be obtained from Best Estimate codes,
  • new generations of codes should provide “internal assessment of uncertainty”
  • information gained in the UMS should be used to inform decisions on the conduct of uncertainty analyses, for example in the light of licensing requirements.

13. Dr. Glaeser drew the following conclusions and general comments from his work:
  • there is considerable interest in uncertainty evaluation from research organisations, utilities and regulators,
  • some potential users wish to improve the practicability of the methods; there is therefore a need for internal assessment of uncertainty, and results from several accident scenarios,
  • uncertainty methods could offer “useful” results from the point of view of a utility wanting to reduce conservatisms (e.g., CSAU applications in the USA),
  • differences in uncertainty distributions found their origin in different experiments used
    • to transform validation results into input parameter distributions and ranges from separate effects experiments, or
    • to determine uncertainty of code results directly by differences between calculated and measured PCT,
  • code uncertainty was partly evaluated directly by determining the differences between calculated and measured values of different experiments investigating the same accident scenario (influence of compensating errors and error propagation, additional uncertainties of plant conditions and fuel related parameters to be quantified),
  • statistical uncertainty evaluation was considered as time consuming (however, USNRC rules recommended a 95 % (or more) probability statement that licensing limits were not exceeded; the alternative consisted of performing a conservative analysis applying Appendix K rules),
  • some organisations preferred a bounding approach using Best Estimate codes with conservative parameter values, initial and boundary conditions,
  • specification of values for uncertain input parameters was necessary for bounding analysis as well as for statistical uncertainty analysis,
  • regulatory guidance was needed for uncertainty analysis.
III. Second session: Alternative methods - Developments under way and proposed
[Chairman: Prof. F. D’Auria, University of Pisa]

14. This session consisted of presentations made by experts more involved in methodology developments. The general objectives were:

• to make an inventory and to analyse actions under way to solve the problems,
• to identify actions of common interest,
• to define suitable orientations for new developments.

15. The first paper in this session, entitled “CIAU Method for Uncertainty Evaluation” was presented by Prof. D’Auria. It covered six parts:

• general frame of uncertainty evaluation,
• flow diagram of UMAE,
• CIAU (Code with capability of Internal Assessment of Uncertainty) definition and needs,
• The idea at the basis of CIAU,
• CIAU diagram,
• CIAU application and developments.

16. At the outset, Prof. D’Auria stressed that code system predictions are not exact; as a consequence, Best Estimate predictions of nuclear power plant scenarios need to be supplemented by uncertainty evaluations in order to be meaningful. The following needs had been identified:

• Code results are affected by user choices. The user of uncertainty methods may also heavily affect results predicted by uncertainty methods. The combination of the two effects may be intolerable.
• The application of any uncertainty method may require expertise and/or resources not easily available.
• The uncertainty must be a characteristics of the code quality or the qualification level.
• Existing uncertainty methods belong to two main categories:
  • methods based on the propagation of input errors,
  • methods based on the propagation of the code output errors.

Most methods belong to the first category. UMAE and the connected CIAU belong to the second category.

The idea behind the CIAU was the “status approach” for nuclear plant transient scenarios:

• Any transient scenario assumed in the reference systems can be characterised by the time and by a limited number of variables. The boundaries of variation for those variables and the time are identified.
• The ranges of variation for those variables and the transient time are sub-divided into intervals. Hypercubes result from the combination of variable intervals.
• The nuclear power plant status is formed by the combination of one hypercube and one time interval.
• It is assumed that uncertainty can be associated to any nuclear power plant status.

Prof. D’Auria presented several examples of CIAU application, and described future developments. CIAU had been applied to the Angra-2 Framatome-ANP NPP LBLOCA analysis and to the Kozloduy-

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2 Prof. D’Auria pointed out that the CIAU method has already been used in the licensing process and safety evaluation of existing nuclear power plants. His presentation could also have been made during the first session of the Workshop.
VVER-440 200 mm break analysis. In the former case, it constituted an independent evaluation made to support the licensing authority analysis of the submission made by industry. In the latter case, the application mainly aimed at demonstrating that the Best Estimate prediction of a code fell into the uncertainty bands of the prediction of another code (the two codes had been applied using the same set of input and boundary conditions). Prof. D’Auria concluded that CIAU constitutes a tool combining a qualified Best Estimate code (RELAP5) and a suitable uncertainty methodology (UMAE). It produced “continuous” error bands.

17. Dr. Ionescu-Bujor presented a paper titled “Status of Applications of the Adjoint Sensitivity / Uncertainty Analysis Procedure (ASAP) to RELAP5/Mod 3.2”. After describing the ASAP objectives and conceptual flow chart, and the ASAP implementation within the RELAP5/Mod 3.2 coupled two-fluid/heat structure model, she presented the objectives of the sensitivity analysis and the Adjoint Sensitivity/Uncertainty Analysis Procedure. The method had been applied to the analysis of a test bundle in the QUENCH facility (QUENCH-04 test). The sensitivities of the central temperature of the unheated central rod had been investigated.

18. Mrs. De Crécy presented a paper entitled “Uncertainty Evaluation - CIRCÉ Tool”. The aim of CIRCÉ was to determine basic uncertainties related to the constitutive relationships, through the use of a statistical methodology. In order to do that, it analysed the results of the tests of the qualification matrix of CATHARE. Its main features were a linear model between these results and the correlations, the use of a criterion of maximum likelihood and the use of the E-M algorithm. The specifications of the application of CIRCÉ to CATHARE had been defined with the partners of the CEA: EDF, Framatome and IRSN. The objective of the programme was to define a systematic methodology in the use of CIRCÉ. Before applying CIRCÉ the database was systematically checked for sufficiency and appropriateness. The results of the application, were also checked. The future programme of work would include a generalisation of CIRCÉ to the non-linear case and a bibliographic study. Mrs. De Crécy presented the following conclusions:

- CIRCÉ is operational and is applied to the correlations of CATHARE, revision 6.
- In spite of the linearity hypothesis, the calculated uncertainties seem correct.
- Efforts are under way to overcome the linearity hypothesis.
- A more important source of error is the limitation of the considered databases.

19. The next paper was presented by Mr. Chojnacki; it was entitle “Methodologies of Uncertainty Propagation Calculation”. After recalling the theoretical principle and the practical difficulties of the methodologies of uncertainty propagation calculation, the author discussed how to propagate input uncertainties. He said there were two kinds of input uncertainty:

- variability: uncertainty due to heterogeneity,
- lack of knowledge: uncertainty due to ignorance.

It was therefore necessary to use two different propagation methods. He demonstrated this in a simple example which he generalised, treating the variability uncertainty by the probability theory and the lack of knowledge uncertainty by the fuzzy theory. He cautioned, however, against the systematic use of probability theory which may lead to unjustifiable and illegitimate precise answers. Mr. Chojnacki’s conclusions were that the importance of distinguishing variability and lack of knowledge increased as the problem was getting more and more complex in terms of number of parameters or time steps, and that it was necessary to develop uncertainty propagation methodologies combining probability theory and fuzzy theory.

20. Dr. Macian presented a paper entitled “Uncertainty in System Codes – Current Status and Future Work in STARS”. The starting point of the paper was a reminder that uncertainty has a
statistical nature. It is therefore quantified by statistical measures: confidence intervals, variances, tolerance intervals, probabilistic density or cumulative probability functions. An uncertainty measure quantifies how reliable a code results are. Complex codes used in many engineering and scientific fields require a measure of the uncertainty of their results. Dr. Macian described uncertainty research at PSI (based on RETRAN-3D) and uncertainty application in STARS, using the GRS approach (SUSA program developed by GRS for the statistical part of the methodology). He also described briefly the new research efforts under way at the Institute. The conclusion of the work was that the methodology under investigation should provide more accurate uncertainty information of the code results than currently available, and a solid basis for the generation of objective uncertainty information for physical models of complex codes. It was applicable to Best Estimate codes and to other complex codes in other scientific and engineering fields. A common disadvantage had been discovered in the above-mentioned uncertainty research: it was necessary to introduce subjective expert opinion. The proposed research plan for the development of the methodology was therefore to obtain objective, statistically sound uncertainty information for code physical models.

21. The last presentation in the session, “Developments in the area of Best Estimate Applications Proposed by the EUROFASTNET – EU Project”, was made by Prof. D’Auria. EUROFASTNET, which had covered the period 1 September 2000 - 28 February 2002, had been a European Commission project for future advances in science and technology for nuclear engineering thermal-hydraulics. It had regrouped some fifteen European industrial organisations, utilities, R&D institutes, safety institutes and university research laboratories. The aim had been to arrive at a common understanding on the key problems and necessary R&D. Among others, R&D proposals had been made in the field of Best Estimate calculations and uncertainty evaluation. These proposals had not yet been fully endorsed by the EUROFASTNET participants.

22. Requirements for future activities or proposals about uncertainty methods had been established having in mind the following strategic objectives:

- The need to better describe the available uncertainty methodologies in order to develop a common understanding about their capabilities. In some cases, those methodologies are the results of wide range investigations that are not properly documented.
- The need to qualify the uncertainty methodologies including the proposal of suitable acceptability thresholds and criteria.
- The need to achieve a commonly accepted comparison between results from best estimate prediction plus uncertainty and conservative predictions. In this way the advantage of uncertainty prediction is fully established and no doubt arises about the convenience from the utility side to adopt the methods.
- The proposal of suitable procedures for the complete application of the uncertainty methods to the licensing process of nuclear power plants involving the Best Estimate evaluation of all the transients that are part of the FSAR.
- The need to plan uncertainty studies and methodologies connected with the development of advanced computation tools.

23. Prof. D’Auria then presented the proposals which had been submitted to the EUROFASTNET participants (stressing that they still had not received full endorsement):

(i) To apply uncertainty methodologies to one relevant LOFT LBLOCA experiment. This can be either L2-5 (utilised for CSNI ISP-13) or any other OECD LOFT Project test. The qualification of the uncertainty methods may constitute the main achievement. Additional objectives can be achieved by proper planning of “parallel” activities.

(ii) To apply the uncertainty methodologies to the LBLOCA analysis of the TMI-1 nuclear power plant. The proposal derives from recognising the availability of full information for
setting up input decks related to the considered nuclear power plant. Advantages of the 
Best Estimate approach plus uncertainty over the conservative approach should be 
characterised.

(iii) To fix acceptability criteria for current uncertainty methodologies. These should include 
the accurate description of the methodology, the user manual (or equivalent), the proofs 
of qualification of the methodology, the discussion about methodology-user effect, the 
demonstration of the application method.

(iv) To review the licensing process making it consistent with a full Best Estimate approach 
that needs the uncertainty. The need for this starts from the consideration that the current 
licensing process is tailored toward the use of conservative methods.

(v) To extend the current methods to the coupled 3-D neutronics / system thermal-hydraulics 
codes finalised to the study of the core performance that needs the system interaction.

(vi) To extend the current methods to the coupled system thermal-hydraulics / CFD (single 
phase and also two-phase) / structural mechanics codes finalised to the study of the PTS 
problem.

(vii) To establish criteria for the consideration of uncertainty by new/advanced codes that are 
being developed in the area. This may include the request “to embed” the uncertainty 
method into the code (Internal Assessment of Uncertainty).

During the discussion, the Secretary pointed out that Proposal (i) would need to be discussed with the 
NEA and the US to ensure availability of data, and Proposal (iv) would need to be rephrased as 
modifying the licensing process was of course not the remit of the EUROFASTNET project.

IV. Third session: Discussion and conclusions on the orientations of the group 
activity – Development of an Action Plan 
[Co-Chairmen: Prof. F. D’Auria, University of Pisa, and Dr. J.-C. Micaelli, IRSN]

24 Opening the discussion, Dr. Micaelli said that the objective of the session was to make a 
synthesis of the Member countries’ views regarding the adequacy of method development/assessment 
under way and regarding the need for additional method evaluations or developments. This synthesis 
would lead to the definition of an Action Plan, and to recommendations to be made to GAMA and the 
CSNI.

25. Possible topics, in Dr. Micaelli’s view, were the following:
   o code adequacy,
   o basic uncertainties and propagation methods,
     o source of uncertainty,
     o quantification methods,
     o incompleteness of models, scaling effects,
     o propagation methods, adequacy,
   o assessment of methodologies,
   o extension of uncertainty methods to severe accidents.

26. On the question of code adequacy, the discussion turned to the identification of transients for 
which existing codes are adequate. Prof. D’Auria said that reference was made to thermal-hydraulic 
system codes coupled with 3-D neutronics codes, possibly coupled with containment codes, adding 
that licensing applications should be kept in mind. Dr. Macian suggested to restrict the discussion to 1-
D neutronics codes but Prof. D’Auria objected that these codes were only a special case - not in very 
common use - of the 3-D neutronics code category. Thermal-hydraulics was one key aspect. 3-D codes
were increasingly used in various fields, in neutronics in particular. Thermal-hydraulics system codes and neutronics codes should therefore be coupled (both the 3-D and the 0-D cases should be considered). At this stage, there was no example, though, of a code coupling thermal-hydraulics, neutronics and containment aspects; two or three codes had to be used to perform complete calculations. Prof. D’Auria said that containment aspects (multi-volume codes) should be covered by thermal-hydraulics system codes, adding that, in deciding on the adequacy of a code, particular sequences should be considered: LBLOCA, SBLOCA, transients and ATWS, both in the 0-D and 3-D cases. Distinction could also be made between PWR aspects and BWR aspects (at least, BWR stability) but it was agreed that this would make the discussion much too detailed. Dr. Micaelli asked the participants if one should first define criteria allowing the user to make a judgement about the adequacy of a code. Opinions were split among the participants on whether this was possible or not given the current state of knowledge. Dr. Réocreux said that experts had been working on this question for twenty years, in particular in the framework of expert groups organised by the NEA, but there was no definite answer yet, although significant progress had been made. In his view, the most likely answer was “in general yes, at least to some extent, but depending on the case”. A system of equations was always an approximation, and this had an effect on the uncertainties. E.g., analysing uncertainties due to the fact that 1-D models rather than 3-D models were used was very important for licensing applications. Dr. Réocreux added that severe accident codes presented particular problems (e.g., the physical models could be wrong, there were approximations on the results, etc.).

27. It was suggested that it would be useful to develop code adequacy criteria and guidance but Dr. Glaeser pointed out that these were available since the 1980s. He and Dr. Réocreux said that part of the problem arose from the fact that code validation work was too often incomplete, because physical analyses did not go far enough and differences between experimental and calculation results were not investigated in detail, and from the fact that too many calculations involved parameter tuning without documentation; scalability of the results was another important consideration (a point also supported by Dr. Micaelli).

28. Prof. D’Auria said that too many people were not aware of the considerable work which had been done in the last two decades, in particular by NEA groups of experts. A very large amount of information was contained in numerous reports published by the CSNI. Means should be found to integrate this documentation in existing activities, to take advantage of it and avoid repeating past successful work unnecessarily.

29. Turning to the question of basic uncertainties and propagation methods, Prof. D’Auria said that the first two sessions of the meeting had brought a very useful updating on existing methods. The following topics had to be considered:

- sources
- method characteristics
- incompleteness and shortcomings

The first two points had been discussed extensively in the past. Future work should concentrate on incompleteness and shortcomings of the uncertainty methods. These could be characterised in the following way:

(i) Probabilistic methods: GRS, CSAU
(ii) Deterministic methods: UK
(iii) Bounding approach: EDF, Tractebel
(iv) Propagation of output error: University of Pisa
Moreover, the Adjoint Sensitivity Method (ASM), used by FZK and CEA Grenoble for evaluating input uncertainties, was a tool which could be used in combination with other methods.

30. With respect to sensitivity analyses, it was agreed that these were an implicit part of uncertainty analysis (e.g., to find worst break locations) and should not be mentioned separately. Prof. D’Auria said that distinction should be made between uncertainty evaluation analyses (to cover possible ranges and/or distributions of calculation results) and studies aimed at identifying the most influential variables.

31. Regarding the assessment of methodologies, Prof. D’Auria said that this was one of the objectives of the UMS. Future work could be extended in that direction.

32. Concerning the extension of uncertainty methods to severe accidents, Prof. D’Auria pointed out that the quality of the codes and the availability of databases were quite different from design basis accident situations; for instance, risk methods could not be extended meaningfully to severe accidents because of the lack of suitable data. Dr. Micaelli added that, in the case of lack of data, the bounding approach was generally used for severe accident studies. On this point, Dr. Réocreux said that the bounding approach did not give much information about safety margins. He added that a number of unsolved problems (e.g., related to operator error, equipment failure, etc.) were affecting PSA Level 2 calculations, and were resulting in very large uncertainties. Dr. Réocreux also mentioned that methods used in structural analysis were quite different from those used in thermal-hydraulics and neutronics; there was a need for increased exchanges in this area. Mr. Marques reinforced this point by saying that mechanics experts were interested not only in uncertainty analysis but also in failure probabilities; for them, tail behaviour was more important than central values. Dr. Réocreux added that structural experts needed information on uncertainties associated with loads resulting from thermal-hydraulics. Prof. D’Auria concluded that this topic was a cross-cutting issue among several CSNI Working Groups (GAMA, Working Group on Risk Assessment WGRISK, and Working Group on Integrity of Components and Structures IAGE).

33. The Secretary pointed out the importance of performing Best Estimate calculations for Severe Accident Management. It was agreed that indeed this aspect should also be considered. An additional difficulty with the extension of uncertainty methods to severe accidents, mentioned during the discussion, was that this work strongly depended on various factors that had influence on the situation preceding the occurrence of the accident, e.g. accident prevention measures.

34. On the basis of the previous discussion, the group adopted the following Action Plan:

(i). Transfer of knowledge gained over the last two decades through CSNI activities such as SOARs, CCVM, user effects, UMS, lessons from ISPs, workshops:
   Transfer of knowledge seminar (2 weeks, University of Pisa or INSTN) (high priority)
(It was pointed out that the idea is not to organise a training course but to concentrate on knowledge and experience acquired through the accumulation and interaction of various CSNI programmes of work; a great part of this expertise is not available elsewhere. GAMA could act as an Organising Committee. Such transfer of knowledge seminars could be organised from time to time.)

(ii). Guidelines for Best Estimate code application to licensing (including coupling with T/H, 3-D neutronics, and uncertainty analysis; interaction with CNRA through questionnaire): Report (18 months) (low priority)
(It was agreed that it would be beneficial to seek guidance from the Committee on Nuclear Regulatory Activities (CNRA), probably through a questionnaire; regulatory organisations will be invited to participate in this work.)
(iii). **Classification of uncertainty propagation methods** (including criteria, advantages/shortcomings, applicability to Severe Accidents):

Report (6-8 months) (medium priority)

(This work would be done by a sub-group of GAMA.)

(iv). **Assessment of methodologies: UMS-2** (including scaling issues, LOFT L2-5, TMI-1 LBLOCA, sensitivity study):

Report (3-4 years) (high priority)

(This work would be done by a sub-group of GAMA. It is related to future work on the re-analysis of ISP-13/LOFT L2-5 test)

(v). **Topical GAMA/WGRISK/IAGE meeting on evaluation of uncertainties in relation to Severe Accidents** (including PSA Level 2, SAM, structural analysis methods):

Proceedings and Conclusions, follow-up work (high priority)

(vi). **Workshop on Best Estimate Codes** (follow-up to Annapolis, Ankara and Barcelona) (in 3-4 years)

V. **Other matters**

35. Dr. Micaelli asked the participants to provide him with electronic versions of the papers they had presented. He will prepare “proceedings” of the meeting (for restricted distribution).

36. On behalf of the group and the NEA, the Secretary thanked Dr. Micealli and the IRSN for their kind hospitality and the arrangements they made for the meeting.