Determination 2006/34

Single means of escape from a high-rise apartment building at 47 Wakefield Street, Auckland City

1 The dispute to be determined

1.1 This is a Determination of a dispute under Part 3 Subpart 1 of the Building Act 2004 ("the Act") made under authorisation by me, John Gardiner, Determinations Manager, Department of Building and Housing, for and on behalf of the Chief Executive of that Department.

1.2 The applicant is Kim's Fortune and Future Ltd.("the applicant") The other parties are Body Corporate 325589 ("the Body Corporate"), the Auckland City Council ("the territorial authority"), and the New Zealand Fire Service Commission ("the Fire Service"), which has the right or obligation to give written notice to the territorial authority in respect of these matters. The matter for Determination relates to compliance with clauses C2 and C3 of the Building Code.

1.3 I take the view that the matter for Determination is whether a modified apartment building ("the building") with a single means of escape from fire complies with clauses C2 and C3 of the Building Code (the First Schedule to the Building Regulations 1992) as required by sections 177 and 188 of the Act.

1.4 In making my decision, I have not considered any other aspects of the Act or the Building Code.

2 Procedure

2.1 The building

2.1.1 The building will become a 10-storey apartment block. The original 8-storey building was converted from offices in 2002. It is proposed to add six two level apartments on top of the existing building. Each new apartment consists of a full floor and an intermediate floor. The modified building has a new escape height of 26.4 from the full floor and 29.25 from the intermediate floor of the top apartment. I note that comment 2 of the definition of escape height in C/AS1 (2001) makes it quite clear

that a building's escape height includes the intermediate floor. Accordingly I have taken 29.25 m as the appropriate escape height for the building.

2.1.2 All the apartments open onto an internal horizontal corridor, which provides access to the stairway and lifts. The building, including both the existing and the proposed areas is sprinkler protected in accordance with NZS 4541, including smoke detectors and manual call points throughout. A hydrant riser main is installed in the building.

2.1.3 A typical floor plan for level 8 is reproduced in Figures 1 and 2 (below).

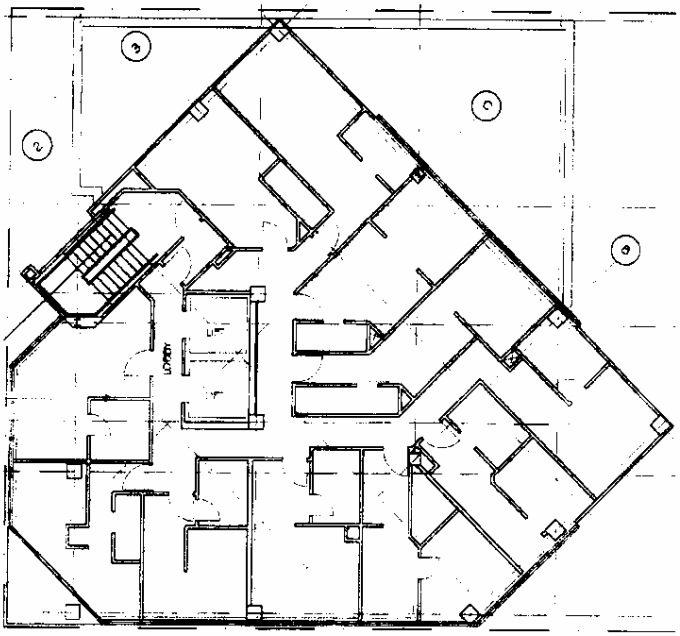

Figure 1: Typical floor plan (existing), reproduced from the EX02 rev -, dated December 2004

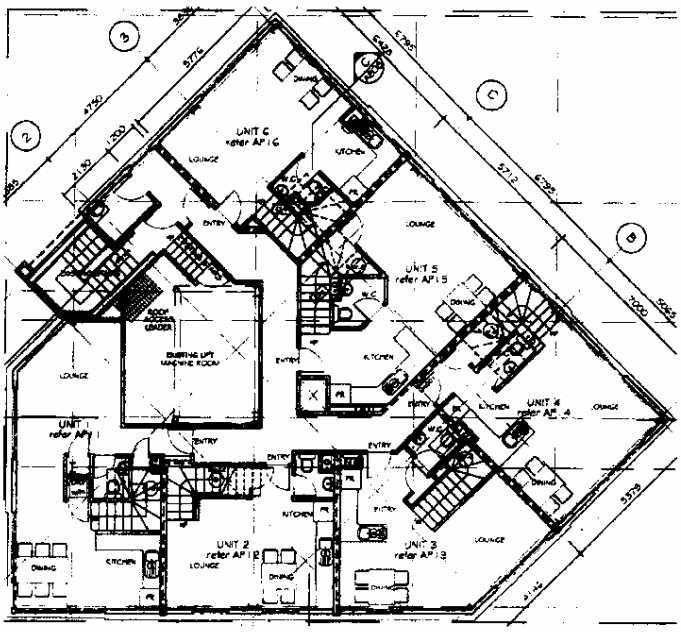

Figure 2: Level 08 Plan, reproduced from AP02 rev -, dated December 2004

2.2 Sequence of events

2.2.1 The penthouse apartments are to be constructed following issue of a building consent which is contingent upon this determination. Initial application for a building consent was made on 23 December 2004. On 24 February 2005, following discussions between the parties, the territorial authority advised the applicant in a letter that as the building had only a single stairway for fire egress, the territorial authority were of the view it is beyond the scope of the acceptable solution of C/AS1.

2.2.2 The applicant's architect's application for a Determination was received on 1 April 2005, with some additional information received after that date.

2.2.3 An independent expert was appointed to prepare a report and this was received in a revised form that was dated 23 August 2005.

2.2.4 After this report was received, it was forwarded to the parties during August 2005. These parties included the Fire Service, as the applicant as required by the Building Act had not forwarded the initial application to them. . The Fire Service responded on 15 September 2005.

3 The submissions

3.1 As part of its submission, the applicant provided copies of:

- A fire report prepared by a specialist fire engineer , "Fire Engineering Design Sun Apartments" dated October 2002 and amended June 2003, This was for the conversion of the original building from office space to apartments
- A fire report prepared by the same specialist fire engineer "Fire Engineering Design Sun Apartment Penthouses, 47 Wakefield Street, Auckland, Issued 20 December 2004" and annotated "Issued for Building Consent"
- A fire report prepared by the same specialised fire engineer "Sun Apartments Penthouses, 47 Wakefield Street Auckland, Fire Engineering Design Addendum March 2005" dated 22 March 2005

3.2 Architectural drawings by the owner's architect titled "Sun Apartments, Penthouse Development, 47 Wakefield St, Auckland City Building Consent Issue, dated 22 December 2004".

3.3 In a note attached to the Application for determination under the Building Act 1991 (Form D1) the applicant's architect noted that the modified building height will exceed the 25m allowance for a single stairway, but that the current building at level 7 is below this. He commented that an alternative solution had been prepared for the proposal but the Auckland City Council would not consider this.

In the addendum report provided in support of the submission to the Department dated 22 March 2005, the applicant's fire engineering consultants described in general terms its negotiations with the Fire Service. The applicant expressed surprise

at the territorial authority's response as the Fire Service had not raised any objections to the design in a meeting..

3.4 The territorial authority the Auckland City Council requested revised plans showing a second means of escape, or a Determination from the department of Building and Housing ("the Department") justifying the design.

3.5 Copies of the submissions and other evidence were provided to each of the parties.

3.6 Correspondence was received from Auckland City, outlining the background and further information was sought from the architect in a letter from the Department dated 10 May2005.

3.7 The Fire Service provided a submission dated 15 September 2005 in response to the independent experts' report.

3.8 The Body Corporate wrote to the Department on 14 December 2005, acknowledging receipt of the draft determination. In this, the Body Corporate stated:

> Body Corporate 325589 is unable to accept the determination. The determination, although comprehensive, assumes in clauses 9.1 that conditions that give rise to your compliance can be achieved. We draw your attention that legislation contained within the Unit Titles Act 1972 and amendments do not allow the required conditions to be conducted without the prior written consent of the Body Corporate. This must be obtained in accordance with the correct procedure a detailed in the Unit Titles Act 1972.

3.9 The Architect wrote to Department by e-mail on 6 February 2006 and I refer to this correspondence in paragraph see 5.11.3.

4 The relevant provisions of the Building Code

4.1.1 The dispute to be determined is whether the territorial authority's decision to refuse a building consent for the building because it was not satisfied that the single means of escape from fire complied with clauses C2 and C3 of the Building Code (First Schedule, Building Regulations 1992) is correct.

4.1.2 The relevant provisions of the building code are:

Clause C2—MEANS OF ESCAPE

OBJECTIVE

C2.1 The objective of this provision is to:

(a) Safeguard people from injury or illness from a fire while escaping to a safe place, and

(b) Facilitate fire rescue operations.

Clause C3—SPREAD OF FIRE

OBJECTIVE

C3.1 The objective of this provision is to:

(a) Safeguard people from injury or illness when evacuating a building during fire.

(b) Provide protection to fire service personnel during fire fighting operations.

(c) Protect adjacent household units, other residential units, and other property from the effects of fire.

(d) Safeguard the environment from adverse effects of fire.

4.1.3 The relevant performance statements deriving from these objectives are incorporated in clauses C2.3 and C3.3 of the Building Code. I note that the applicant is required to satisfy these latter performance requirements in order to comply with the Building Code.

4.2 Fire safety features necessary to comply with the Acceptable Solution

4.2.1 The relevant provisions of the Acceptable Solution C/AS1 amount to a means of compliance with the performance requirements of clauses C2 and C3 of the Building Code.

4.2.2 In order to comply with the Acceptable Solution C/AS1, a new sprinklered multi-unit residential dwelling (Purpose Group SR) having an escape height from fire of 29.25m (10 floors) and containing the same apartments and rooms as the proposed addition would be required to have the following significant fire safety features:

- an automatic fire sprinkler system with smoke detectors and manual call points (allowing local notification of smoke detector activation in the apartments), ie a Type 5 system
- two separate means of escape stairways separated by fire rated construction
- a fire cell rating of no less than F30
- fire separations of the safe path to be 30/30/30 (reduced from 60/60/60 due to provision of sprinklers)
- lifts within a protected shaft
- exit doors from the apartments required to open directly onto a horizontal safe path, a pressurised vertical safe path, or a final exit
- a horizontal protected path at each floor level (other than the top floor) preceding the vertical safe path. The protected path and vertical safe path are to be separated by fire doors.

4.2.3 There are no Acceptable Solution's that have been approved under section 22 of the Act or section 49 of the Building Act 1991 that cover single means of escape for buildings of this configuration and size. I am, therefore of the opinion that the system proposed to be installed must now be considered to be an alternative solution.

4.3 Fire safety features proposed as an alternative solution

4.3.1 The relevant provisions of the current version Acceptable Solution C/AS1 amount to a means of compliance with the performance requirements of clauses C2 and C3 of the Building Code. I note that, at the time the original 2002 alteration was undertaken, a previous (2001) edition of the C/AS1 was operative, and I comment on aspects of that later in my evaluation.

4.3.2 The proposed building therefore differs from one complying with C/AS1 in that:

(a) It has a single escape route instead of the two required for a sprinklered building with an escape height exceeding 25 m.

(b) The smoke alarm system within the apartments has been installed to NZS 4514: 2002 which is a lesser standard than that currently expected for a complying Type 5 alarm and indeed is a lesser standard than should have been installed in 2002 if strictly to C/AS1.

(c) Safe paths are provided, but there is no pressurisation.

(d) Fire hose reels are provided.

(e) There is emergency lighting in exitways.

(f) There is a fire hydrant system.

4.3.3 With respect to the abovementioned features, the expert has noted (see Section 5 following) that:

(a) as the smoke alarm system referred to in paragraph 4.3.2(c), is an existing system, it may not be "reasonably practicable" to upgrade it.

(b) the absence of pressurisation referred to in paragraph 4.3.2(d) is of concern.

4.4 Alternative Solutions and Acceptable Solutions

4.4.1 In comparing an alternative solution with an Acceptable Solution it is useful to bear in mind the objectives of the relevant Building Code clauses.

4.4.2 The applicant's fire safety consultant contended that the design is an alternative solution complying with the Building Code but not with the Acceptable Solution C/AS1.

4.4.3 With regard to this contention, I note that the Authority said in Determination 2004/5:

"5.2.2 As for the proposed alternative solutions, the Authority's task is to determine whether they comply with the performance-based Building Code.

In doing so, the Authority may use the Acceptable Solution as a guideline or benchmark[1].

5.2.3 The Authority sees the Acceptable Solution C/AS1 as an example of the level of fire safety required by the Building Code. Any departure from the Acceptable Solution must achieve the same level of safety if it is to be accepted as an alternative solution complying with the Building Code.

5.2.4 As in several previous Determinations, the Authority makes the following general observations about Acceptable Solutions and alternative solutions:

(a) Some Acceptable Solutions cover the worst case so that in less extreme cases they may be modified and the resulting alternative solution will still comply with the Building Code.

(b) Usually, however, when there is non-compliance with one provision of an Acceptable Solution it will be necessary to add some other provision to compensate for that in order to comply with the Building Code."

4.4.4 In the light of comments made separately, I then stated:

"I accept that the Authority's reference to "the worst case" is too broadly worded in an application of this type. A better formulation would be:

(a) Some Acceptable Solutions cover the worst case of a building closely similar to the building concerned. If the building concerned presents a less extreme case, then some provisions of the Acceptable Solution may be waived or modified (because they are excessive for the building concerned) and the resulting alternative solution will still comply with the Building Code.

(b) Usually, however, when there is non-compliance with one provision of an Acceptable Solution it will be necessary to add some other provision or provisions in order to comply with the Building Code."

4.4.5 I note also that this application involves an alteration, as defined under Section 112 of the Act.

This section states:

"112 Alterations to existing Buildings

(1) A building consent authority must not grant a building consent for the alteration of an existing building, or part of an existing building, unless the building consent authority is satisfied that, after the alteration the building will –

"[1] *Auckland CC v NZ Fire Service* [1996] 1 NZLR 330."

a. comply, as nearly as is reasonably practicable, with the provisions of the building code that relate to-

i. means of escape from fire; and

ii. access and facilities for persons with disabilities….."

4.4.6 In previous determinations, such as Determination 2004/05 the Building Industry Authority considered the manner in which territorial authorities might address the need for an owner to upgrade its buildings to an extent that they achieved compliance "as nearly as is reasonably practicable" as if it were a new building.

In this particular case, I have decided that I should evaluate the building as if it were a new building, and then later consider the practicability of upgrading once the fully compliant upgrade requirements are known. I have given no consideration to the consequences arising from section 112(2).

5 The experts' report

5.1 On receipt of the application, I commissioned an expert ("the experts") to report on the fire safety features of the building. The experts' report provides specific information on the single means of escape from fire in the building. The main features of the experts' report can be summarised under the following general headings:

- Introduction
- Description of the building
- Design philosophy
- Methodology
- Risk identification
- Risk analysis
- Risk evaluation
- Results
- Outcome.

5.2 Introduction

5.2.1 The experts used documents provided by the Department, including the reports prepared on behalf of the applicant, to evaluate the application. These documents are listed in paragraphs 3.1 to 3.3.

5.2.2 Further information was provided in an email dated 21 June 2005 in response to the experts' request for further information dated 9 April 2005.

5.2.3 The expert conducted a site inspection dated 12 July 2005

5.3 Description of the building

5.3.1 The experts described the existing building with its added penthouse in relation to its fire safety aspects and noted the reasons why the determination was sought. They outlined the features that the designers had introduced to compensate for the absence of one means of escape (stairway). In particular, this involved the extension of the Type 7e automatic fire sprinkler system with smoke detectors and manual call points, fire hose reels, emergency lighting in exit ways, and a fire hydrant system, and the upgrading of the water supply from Class C to Class B1

5.3.2 For the purposes of analysis, the experts analysed two buildings. One of these being the subject building, referred to hereinafter as Building A. This building is then compared with an "idealised" building, referred to as Building C in the risk assessment. Building C is of the same height, plan area, and occupant load as Building A, but as it has two stairways, it complies with C/AS1.

5.3.3 Referring to the manner in which a comparative analysis is carried out, I note that in Determination 2004/65 the Authority has said:

> "6.1.1 The Authority takes the view that as a matter of law this Determination is binding only on the parties and only in respect of the building concerned.
>
> 6.1.2 Nevertheless, the Authority recognises that people considering other buildings will frequently use a Determination for guidance. The Authority therefore tends to set out its reasoning in more detail than may be strictly necessary for the particular case, in the hope that the reasoning, as distinct from the conclusions, will be of use as an example of the process of arriving at a decision in a different case involving comparable circumstances.

5.3.4 I take the same view in this case, but also note that this building and particularly its configuration and floor layout are not common. Any broader interpretation of the conclusions of this Determination must acknowledge that fact.

5.3.5 Figure 3 (below) shows the floor plans for the idealised building, Building C (the corresponding building deemed to comply with C/AS1). Fig 2 (page 3) shows the design for building A.

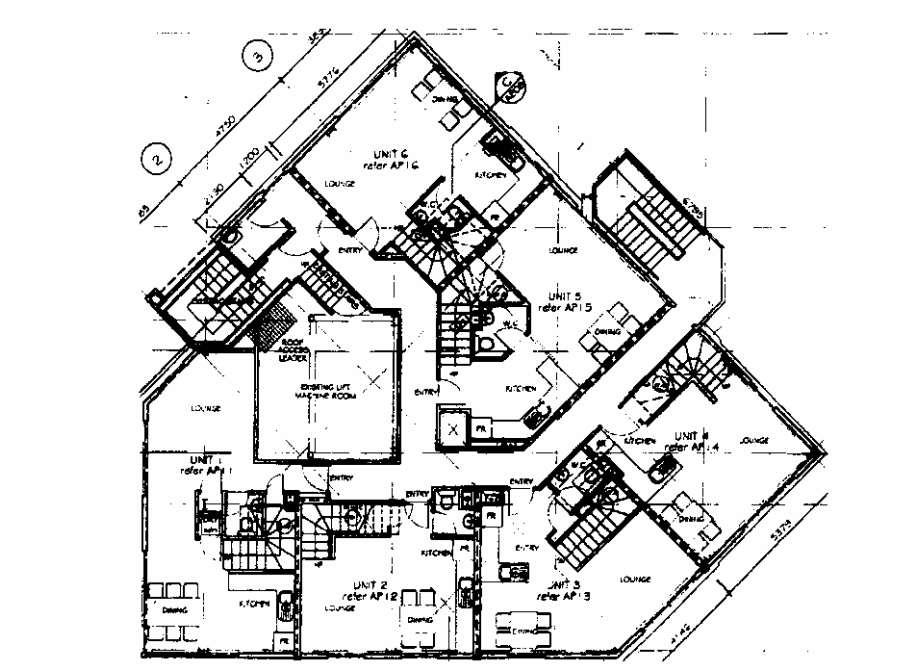

Fig. 3. Compliant building – Building C. (Note additional stairwell upper right)

5.4 Risk Design philosophy

5.4.1 The International Fire Engineering Guidelines (IFEG), published in 2005 and recognised as a benchmark of good practice, has establish that any alternative solution, other than the simplest such cases, must be justified on a quantitative basis. The key issue is whether the single means of escape, incorporating the compensating features, which are the improvements to the sprinkler system and the stairway pressurisation system in Building A, are sufficient to offset the loss of the second stairway provided in Building C. In the experts' view, the most suitable methods of analysis to establish the impact of these various elements on levels of fire safety are probabilistic-comparative or probabilistic-absolute. Previously, most analysis was based on deterministic methodologies.

5.4.2 The experts then referred to Determination 2005/109, which established that a probabilistic-comparative approach is the more appropriate analysis method for cases such as this, without precluding the probabilistic-absolute approach. Determination 2005/109 had considered the fire safety compliance of an 18-storey multi-unit apartment building, with a smaller floor plate area than the subject building, in terms of how its features compare with the corresponding (C/AS1) Acceptable Solution building.

5.4.3 Specifically at paragraph 6.2.4 of that Determination, I said:

> "…I consider that the type of comparative risk analysis used in the assessment is an appropriate method for deciding whether an alternative solution is effectively equivalent to the corresponding Acceptable Solution in terms of fire safety. In particular, I accept the following comment from Expert D (a consultant engaged for that matter) as below:"

> "In considering changes to the fire safety system in a building of the sort proposed, (deletion of a stairway, improvements to the sprinkler system, stairway pressurization, etc) it needs to be understood that each of these changes affects the level of fire safety in the building in different ways. Consequently the only way of comparing these changes is on a risk basis – how much (and in which direction) each of them changes the level of safety in the building."

5.4.4 I am aware that there are some in the fire engineering community who favour absolute approaches, whether deterministic or probabilistic. I am of the opinion that a deterministic approach is not appropriate in this case and the current construct of the Building Code is such that there is insufficient information for an absolute approach. By this, I mean that there is no information as to the quantified tolerable or acceptable levels of risk to be used as a measuring point of compliance. Until these are developed, a probabilistic-comparative approach, with the acceptable solutions as the comparator, remains the most appropriate means of analysing these issues.

5.4.5 In the current case, the experts noted that the report "Fire Engineering Design, Sun Apartments" prepared by the applicant's fire engineer was based on a deterministic methodology. As such, according to the experts, this report did not provide sufficient grounds to determine code compliance. The experts acknowledged that the report was, however, produced before Determination 2005/109 was issued. That Determination set a new benchmark for the analysis methodology.

5.5 Methodology

5.5.1 The experts stated that the assessment of the single means of escape for the apartments requires a risk-based approach. This involves undertaking a risk assessment. Risk assessment is defined as the overall process of:

- risk identification
- risk analysis
- risk evaluation.

5.5.2 This process and structure is consistent with that defined in AS/NZS 4360 "Risk Management". I describe these more fully in the following paragraphs.

5.6 Risk identification

5.6.1 The experts defined risk identification as "the process of determining what, where, when, why, and how something could happen". The risk identification in the context of their assessment is primarily concerned with the impact on life safety, taking into account the escape stairway contribution within the applicant's Building A, as compared to the corresponding compliant Building C.

5.6.2 The primary scenario that is evaluated by the experts is that arising from a fire in an apartment. The following paragraphs are structured around this scenario. It evaluates the risk to the occupants of both the apartment of fire origin and the occupants of apartments on the same floor level and above, should the fire spread. An additional risk relating to an arson "attack" was also considered as a unique hazard analysis.

Arson scenarios are not generally considered in fire designs as a "credible worst case". However, given the nature of the alternative solution (single stair), it was deemed to be particularly vulnerable to such a threat and worthy of individual analysis.

5.7 Risk analysis

5.7.1 Design philosophy

5.7.1.1 The design philosophy that is being proposed and tested in the risk analysis is that as Building A lacks a second stair in comparison to Building C, it needs to have sufficient compensation to overcome this difference in design features. In this case, the compensation is mainly the enhanced sprinkler system and the stairwell pressurisation system (not as designed but as proposed following risk analysis)

5.7.1.2 In apartment buildings, the majority of fire related casualties occur in the apartment of fire origin. The risk of these casualties is therefore relatively insensitive to the number of stairwells. It is sensitive to the overall reliability of the sprinkler system. The greater the probability that a sprinkler will detect and extinguish a fire, the lower the fire casualty risk both to the occupants of the apartment of fire origin and other occupants. However, this gain may not adequately compensate for the absence of a second stair and a pressurisation system is offered up as a means of further improving the safety outcomes should the enhanced sprinkler system not control the fire and it extends to the stairwell. A pressurisation system is designed to ensure that an escape route remains substantively clear of fire products (e.g. smoke)

5.7.2 Event tree analysis

5.7.2.1 The experts developed an event tree for both Building A (termed "Event Tree A" or "ET-A") and for Building C ("ET-C"). A sequence of events, including their probability distributions, resulted in a number of outcome scenarios. The events are summarised in the following Table 1, which is reproduced from the experts' report.

Table 1: Summary of Events

Event	Description of event
1	Ignition occurs (initiating frequency)
2	Fire origin is in an apartment
3	Fire growth is limited, i.e.; not a flaming fire that would cause detection in an operating detector and untenable conditions are not reached
4	The occupant is awake
5	There is manual suppression or the fire self extinguishes and untenable conditions are not reached
6	The automatic suppression system (sprinkler system) is effective and untenable conditions are not reached
7	There is automatic alarm is effective and warning is given

8	The first fire separation (barrier 1) between the apartment and corridor is effective
9	Given that the first fire separation (barrier 1) has failed, the second fire separation (barrier 2) is effective between the corridor and Stair I
10	Given that the first fire separation (barrier 1) has failed, the second fire separation (barrier 2) fails or not, the third fire separation (barrier 3) is effective
11	The pressurisation system is effective

5.7.3 Probabilities

5.7.3.1 The event trees for each building are simplified, share the same layout, and are based on the same template. The experts noted that the probabilities varied between the event trees, particularly as regards the comparable sprinkler systems and number of stairways.. The "ET-A" and "ET-C" buildings are constructed to test the points of difference between the two buildings. These points of difference (or compensation) are:

- Building A in comparison with Building C has an enhanced sprinkler system as it has two independent water supplies, one of which is an in-situ tank supply
- Building A lacks a safe path corridor and a second stair for which a pressurisation system is substituted.

5.7.3.2 The report gave an in-depth explanation of the probability data used in the analysis for events 4 and 6 to 11 within the "Events Summary" table. For each event the effectiveness was identified in two components; viz reliability and efficacy. Effectiveness is defined as the probability that the system operates on demand and efficacy is defined as the degree to which a system achieves that objective given that it operates. The conclusions reached for each of these events are summarised in 'Table 6' from the experts' report, an adaptation of which is reproduced below:

Table 2: Events Probability

Event	Description	Probability
4	Occupant awake	The probability assumption is a Normal distribution with a mean of 0.79 and standard deviation of 0.08.
6	Sprinkler system effective	For Building A, the efficacy is .95 with a Uniform reliability function over the range 0.94 to 0.98 For Building C, the efficacy is .95 with a Uniform reliability function over the range 0.93 to 0.97

7	Automatic alarm	The efficacy is taken as 0.90 with the reliability as a normal distribution with a mean of 0.90 and a standard distribution of 0.05
8, 9, 10	Barrier effective	For Buildings A and C (Lightweight partitions), the efficacy is 1.00 with a Uniform reliability distribution over the range .48 to .68.
11	Pressurisation effective	The efficacy is.75 with a uniform reliability distribution from .50 to 1.

5.7.4 Consequences of each scenario

5.7.4.1 Up to this point, the analysis has considered, via the event trees, sequences that lead to credible scenarios and the **probabilities** that these scenarios will occur. The experts' report then begins the task of calculating the **consequence** of each scenario by undertaking a time dependent analysis. Given a particular scenario, the probability of a negative escape time margin is calculated as a function of Available Safe Egress Time (ASET) vs. Required Safe Egress Time (RSET).

5.7.4.2 The following definitions apply:

Available Safe Egress Time

The available safe egress time is the time between the start of a fire and the time to untenable conditions, i.e. the time to when escape is no longer deemed possible.

The mathematical expression for ASET is:

$$ASET = S \times U_s$$

Where S is the time to untenable conditions, and U_s is an uncertainty factor.

Required Safe Egress Time

The required safe egress time is the time that is actually needed for the occupants to evacuate to a place of safety.

The mathematical expression for RSET is:

$$RSET = t_d + t_i + t_r + t_e$$

Where:

- t_d is the time to detection:
- t_i is the investigation time
- t_r is the occupant response time
- t_e is the occupant movement time

The required result for a safe building is that ASET is greater than RSET so that the available safe egress time is longer than the time for the occupants to escape before untenable conditions are experienced.

5.7.5 Calculation of risk

5.7.5.1 The calculation is made for the range of credible scenarios identified by the event tree. For each of these scenarios the risk calculation has calculated a probability that the escape time margin is less than zero. The risk is calculated by multiplying the cumulative probability of the specific scenario by its consequence. The consequence is the probability of a negative escape time margin (G) multiplied by the number of people exposed. The total risk is then the summation of all the partial risks.

5.7.5.2 The calculation is complex. For this analysis a computer programme (@RISK) was used. The analysis is probabilistic, using stochastic rates rather than discrete values and using a Monte-Carlo calculation engine to compute the values.

5.8 Risk evaluation

5.8.1 The experts' report notes that the risk evaluation criterion is comparative-probabilistic. The risk profiles of the two buildings are directly compared, and Building A is deemed to succeed where "the risk profile is less than that that of Building C, with the inclusion of a safety margin". The "individual risk of fatality" is the risk measure used in the expert's analysis, and was the one used in Determination 2005/134.

5.8.2 This assessment assumes that injury is proportional to fatality, that is that if Building A has a lower risk of fatality than Building C, then the injury rate is also lower. The assessment also does not include events that might have occurred prior to the fire event in an apartment. The unit of risk is not related to frequency and the measure of risk is not a complete profile. However, the experts noted that this approach is valid in terms of a comparative analysis.

5.9 Results

5.9.1 General

5.9.1.1 Using the risk management framework explained above, the expert conducted seven different analyses of the building. They were:

(1) As proposed in building consent

(2) Base case with an enhanced sprinkler system and effective pressurisation, with time dependent effects

(3) A variation of Base case without the sprinkler enhancement, with time dependent effects

(4) A variation of Base case without modelling time dependent effects

(5) A variation of Base case without time dependent effects and without the sprinkler enhancement

(6) A variation of Base case with low efficacy pressurisation system.

(7) A variation of Base case with no pressurisation system,

5.9.1.2 The purpose of the various analyses is to look at the "sensitivity" of the margin to various design features.

5.9.1.3 The results from the experts' base case analysis of the subject Building A in comparison to the C/AS1 compliant building (Building C) are given graphically in Figure 4 (below). This is the base case which is not as proposed in the building consent application but includes enhancements. Table 3 is a summary of the analysis for all seven cases that were evaluated.

5.9.1.4 The graphs are generated from the outputs from the @RISK computer programme. The risk profiles of the two buildings from the @RISK computer analysis are overlaid on each other to show the risk profiles of the buildings in relation to each other. This shows the risk profile for the proposed building (Building A) sitting to the left of the corresponding profile of the control building (Building C), and indicates that Building A has a lower risk in the event of fire. The second graph shows the risk margin, and is the net risk profile of Building C minus the net risk profile of Building A. The result shows that there is a margin of 77% in the base case.

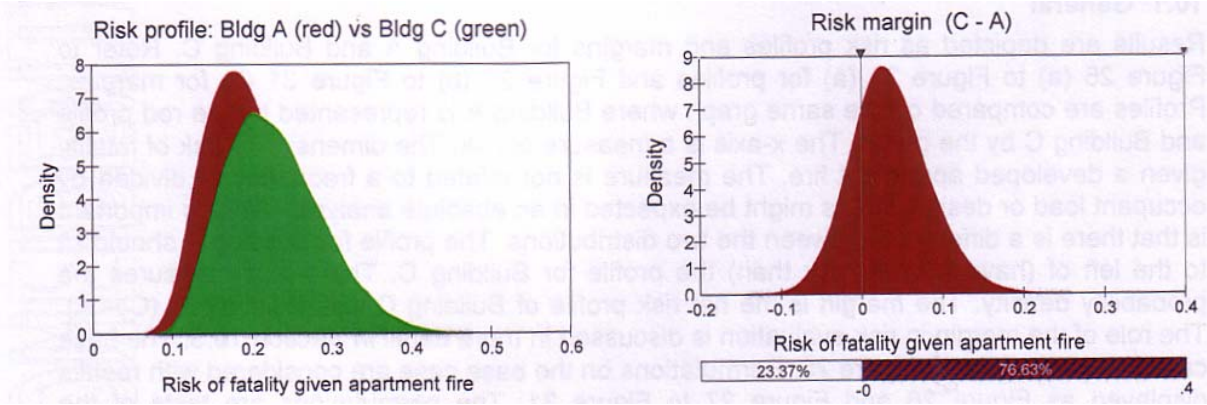

Fig. 4. Risk comparison of Building C and Building A.

The permutations outlined in 5.9.1.1 were considered with combinations of different systems and the effect on the margin is demonstrated in the table below

Table 3: Summary of Results

Analysis	Description	Model time dependent	Sprinkler enhanced	Pressurisation		Margin
				Present	Effective	P(C-A)>0
1	As proposed in Building Consent	Yes	No	No	0%	1%
2	Base case	Yes	Yes, 1%	Yes	68%	77%
3	As per 2 without 1% sprinkler enhancement for Bldg A	Yes	No	Yes	68%	66%
4	As per 2 without modelling time dependent effects	No	Yes, 1%	Yes	68%	81%
5	As per 4 and without 1% sprinkler enhancement for bldg A	No	No	Yes	68%	71%
6	As per 2 with low-efficacy pressurisation system	Yes	Yes, 1%	No	34%	46%
7	As per 6 with no pressurisation system	Yes	Yes, 1%	No	0%	20%

5.9.1.5 The experts noted that two comparable or equivalent buildings will have a margin of 50%. The possibility that things will go randomly wrong in Building A compared with things going right in Building C will mean that the comparison will have a distribution even if they were designed exactly the same. However, in addition to random variability in the input parameters, there is also uncertainty and this may lead to error. To compensate for this uncertainty, a margin of greater than 50% is sought.

5.9.1.6 The experts point out that in Determination 2005/109, 74% for the base case was not considered high enough. The corresponding margin for Building A in the current analysis is 77% (for the base case), which is above the upper limit of Determination 2005/109. It should be noted that these values are not directly comparable. Determination 2005/109 did not consider time-dependent effects, and if it had, it is the experts' opinion that the margin would have been lower, meaning that the difference between the margins in the two buildings (that in Determination 109 and this building) is greater.

5.9.1.7 Analysis 1 represents the pre-determination case without any enhancements and lacking the second stair. The margin reduces considerably from 77% to 1%.

5.9.1.8 Analysis 2 represents the base case with an enhanced sprinkler system and effective pressurisation The margin is 77%.

5.9.1.9 Analysis 3 is paired to Analysis 2 and represents that base case but without the enhanced sprinkler system. The margin is reduced from 77% to 66%

5.9.1.10 Analysis 4 represents the base case but without modelling time dependent effects. The margin is 81% indicating that time dependent **modelling slightly favours building C and is therefore included.**

5.9.1.10 Analysis 5 is paired to Analysis 2 and represents the base case but without modelling time dependent effects and without including a 1% sprinkler enhancement. The margin is 71% which when compared to 81% shows the sensitivity of the sprinkler system.

5.9.1.11 Analysis 6 represents the base case but with a low efficacy pressurisation system. The efficacy is halved from 75% to 37.5%. The margin is reduced from base case 77% to 46% (<50%)

5.9.1.12 Analysis 7 is paired to 6 above, and represents no pressurisation but enhanced sprinklers. The margin is reduced from base case 77% to 20% (<50%)

5.10 Outcome

5.10.1 The experts' report concluded that, in their view, and subject to some specific qualifications, Building A is equivalent to, or is better than, a comparable Building C that complies with the prescriptive Acceptable Solution. There are reasonable grounds to assume that the proposed alternative solution, as represented by Building A, complies with the Building Code. This conclusion was subject to the following conditions (which I paraphrase below): (Note: I reiterate the point that Building A, the base case, is not the building as proposed in the consent, see 5.9.1.1)

- The sprinkler system water supply is to be a Class A supply, as defined in NZS 4541 2003, which is a primary tank supply with a secondary town mains supply. Complete and unambiguous plans and specifications are to be supplied to the satisfaction of the territorial authority.

- The stairway pressurisation system is to be designed installed and commissioned in accordance with the Standard AS 1668.1:1998. Plans and specifications are to be supplied to the satisfaction of the territorial authority.

- The fire engineer is to monitor construction to a level and frequency agreed with the territorial authority and provide a "Producer Statement of Construction Review" to the satisfaction of the territorial authority on completion.

- Doors are not to be locked from the stairwell side in a manner that would prevent occupants from being able to enter any floor level from the stairwell in fire alarm conditions.

5.11 Comments on experts' report by the parties

5.11.1 Copies of the experts' report were provided to each of the parties. The territorial authority accepted the report without comment.

5.11.2 The Fire Service's comments

5.11.2.1 The Fire Service, by letter dated 15 September 2005, made a number of comments on the experts' methodology, recording in particular its view that:

> "analysis of major departures from the Approved Documents must be assessed by quantitative risk assessment techniques", but that, as noted in paragraph 6.2.5 of Determination 2005/109, "the chief drawback associated with this technique at present is the lack of adequate data".

5.11.2.2 With regard to the process of establishing the probability that the alternative solution (Building A) is at least as safe as the Acceptable Solution (Building C); they said:

> "given the uncertainty in the assumed data, this amounts to an attempt to establish the confidence or margin associated with an assertion that the alternative design is at least as safe as a compliant design. Determination 2005/109 states that a probability range, [in the margin], of 51% to 74% is not high enough. The question remains as to what is high enough. The independent expert has assumed that a margin of 77% is enough to demonstrate compliance with the Building Code. The Fire Service cannot comment on whether this value is correct, as it would require an extensive study of the uncertainties in the assumptions. Such a general study is clearly required as a matter of urgency if alternative solutions of this type are to be approved."

5.11.2.3 With respect to the "arson scenario", it states:

> "Single means of escape buildings are more vulnerable than buildings with two stairways to an arson attack, or other fire, in the staircase… Rather than being a "one-off hazard check", as undertaken by the independent expert, the fire within stairway scenario should have been integrated into the risk analysis, modifying the calculated "margin"."

5.11.2.4 With regard to passive fire safety systems it recommended that:

> "given the reliance on fire resisting barriers in the design, conditions should be placed on any building consent relating to inspection during, and on completion of, construction. Final inspection should be conducted by a suitably qualified expert documentation required as to the integrity and construction methods of all fire barriers."

5.11.2.5 With regard to "active fire systems", it recommended that:

> "…the compliance schedule for the building includes an appropriate testing and inspection regime complying with relevant standards for all active systems to ensure ongoing compliance…" and noted the approach I had taken in Determination 2005/109."

5.11.3 The Architect's comments

5.11.3.1 In an email to the Department sent on 9 September 2005, the applicant's architect queried certain aspects of the expert's report in detail. The queries can be summarised as:

1. Why is a pressurised corridor required?

2. If additional smoke-stop doors are not a sufficient enhancement, has the Department considered the creation of a lobby between the corridor and the stairwell?

3. If the previous option still not sufficient, then a controllable environment in each lobby could be created.

4. Finally, if the previous options are insufficient, then extract fans can be installed at the other end of the corridor.

The architect stated that he could not understand why the rationale, that fire design would be no different if the building at its present height had a larger footprint and up to 50 people on each floor, was ignored. Similarly, while the building's proposed 9+ floors could have similar statistical distortions, the expert's conclusion is essentially the same.

6 My response to comments on the expert's report and the draft Determination

6.1 The draft Determination was sent to the parties on 6 December 2005. In a further email to the Department sent on 17 December 2005, the architect noted that the draft Determination did not address the concerns raised in the previous email of 9 September 2005. The architect also stated that the applicant did not accept the draft Determination as there was little evidence that all the options had been considered.

6.2 Concerning the emails of 9 September 2005 and 17 December 2005 from the applicant's architect, I have received the following responses from the expert with which I also concur:

1. For the proposal to be comparable to a two-stair building, the stairwell pressurisation system is a must. The results indicate that without it, the margin varies from 1% to 20% (depending on the class of the sprinkler system) against a target of 75%.

2. Although the addition of further smoke stop doors does not appear as one of the permutations in the results (where seven different cases are reported) it was tried during the trial designs and rejected because the margin was too low with it and without the pressurisation. There were also some secondary problems, such as some apartments being common to the stair and it therefore not being an extra barrier for them. Concerning the comments relating to the smoke stop door additions apply to the creation of floor lobbies.

3 What is being suggested for a controllable environment in each lobby sounds like a corridor pressurisation system which may work in theory but is:
(i) going to be more costly than a stairwell pressurisation system, and

(ii) is not acceptable unless the stairwell is also pressurised (where the stair is enclosed), because otherwise there is a negative pressure differential between the corridor and the stair.

4 The installation of extract fans is not acceptable as it would give a negative pressure differential between an apartment and the corridor

6.3 The point made by the architect concerning building heights and footprints, is that the Acceptable Solution would allow a building of the same escape height as the existing building (prior to the additional storeys) with a single stair but with a significantly higher occupant load. The implication is that a higher occupant load means a higher risk. As noted by my expert, this is a misconception. The applied measure of risk is "individual risk". Following, is a definition of individual risk, from Keey (2000):

> **Risk, individual** the annual probability of harm (injury or death) to a given person in a particular place from a specified incident.

It is therefore fundamental to understand that individual risk applies to "a given person". Whilst there is admittedly a higher fire risk to *someone* within a more densely populated building it is correspondingly lower to any *given* person in that building. It is believed that this is one of the reasons why, in Determination 2005/109 (DBH 2005a), Expert D made the following comment::

> It is not usual, and in-principle is incorrect, to use buildings not otherwise similar to the subject building as the basis for comparison of risk.
>
> Consequently, I do not accept the architect's objection on this point.

6 4 Of the comments of the Fire Service I make the following points. On the question of the margin, I discuss this later. Regarding the arson scenario, I note the comments of the Fire Service on the desirability of the inclusion of the arson scenario (or fires from any other cause outside of an apartment) within the main risk analysis, rather than as a "one-off hazard check" in parallel. I agree with those comments in the long run. However, at this stage, there is limited data to allow these to be included directly in such analysis. At the current stage of knowledge I believe the "one off hazard check" is the best means of analysing the risk of fires from these causes. I do endorse the need for these scenarios to be considered.

6.5 In its letter to the Department of 4 December 2005, the Body Corporate stated that it was unable to accept the draft determination. Paragraph 9.1 of the Determination sets out the conditions that I consider are necessary to make the building comply with the relevant clauses of the Building Code. In accordance with section 188 of the Act, these conditions are binding on the parties, which include the Body Corporate. I am not aware of any legislation that would exempt the Body Corporate from following the conditions that I have set down, notwithstanding the practical difficulty that might be involved. However, if I am mistaken as regards this issue, and the Body Corporate lawfully decides not to comply with the conditions set down in paragraph 9.1, then the building will not receive a code compliance certificate. In addition, the territorial authority might consider that the building as it stands is not safe in terms of section 121(1)(b) of the Act. If this is the case, then under section 124(1) the

territorial authority can require the building owners to carry out rectification work to reduce or remove the danger.

7 Discussion

7.1 General

7.1.1 I have considered the submissions of the parties, the experts' report and the other evidence presented in this matter. I have also considered the applicant's response to the draft Determination. With regard to the latter response, I am of the opinion that the points raised in it have been appropriately answered. Accordingly, I have not amended the conclusions and decision set out in the draft Determination. The approach in determining whether building work complies with clauses C2 and C3 is to examine the design of the building and the design features that are intended to prevent the loss of life. I have described this process previously in Determination 2005/109, which addressed a similar matter, and I have taken that material into account in the current Determination.

7.1.2 As noted in paragraph 4.4.5, this design involves alterations to an existing building as is subject to section 112 of the Act. I note that none of the parties has referred to this point in their submissions.

> Having considered the experts' report, the sensitivity analysis report in paragraph 5.9 (and Table 3), and the submissions from the parties (particularly from the Fire Service), I consider that in this case I have no need to re-set the fire safety thresholds for acceptable performance merely because relief is potentially available to the applicant under section 112. This is because all conditions listed in paragraph 5.10 are, in my view, "reasonably practicable" conditions.

7.2 Is the building code compliant?

7.2.1 I have considered the comparative analysis undertaken by the experts, alongside the other information provided to me about the building, and note the following.

7.2.2 The experts have indicated a comparative margin in the base case of 77% against a target range of 50% to 75%.

7.2.3 There are a number of issues to be evaluated in determining whether the building is code compliant or not in this case. Firstly there is the question of the comparative probabilistic risk assessment and the results of it. More specifically what does the margin mean and how does it relate to other compliance measures? Secondly there is a consideration of the on-going compliance of this building with the Building Code.

7.2.4 Whilst this current result is, on the face of it, marginally superior to that reported earlier for the building described in Determination 2005/109, that of itself is not sufficient to provide me with reasonable grounds on which to decide compliance. It is clear that, taken overall, the safety of occupants within a building of this type hangs on whether the two most critical compensation components, namely the

pressurisation system and sprinkler system, are well designed and robust. These are clearly first order effects, to be evaluated before efficacy and reliability tests are applied.

7.2.5 With regard to the probabilistic risk assessment, the Department's experts have recommended that I accept 75% as the threshold for the margin. To put it another way, this means that there should be a 25% increase in probability that the alternative building will be better than the compliant building. This extra buffer is required in part because the actual probability distribution may not be a pure random variable as assumed in the experts' analysis. As noted in the Fire Service's comments, more analysis is required before a numerical value can be described to an appropriate margin. Even once one has been developed, this will not take away the need for other factors such as the quality of the overall fire design to be factored into the acceptance criteria.

7.2.6 As discussed in paragraph 7.1.2 that this consent is subject to clause 112 of the Building Act. Therefore there is an argument that the target margin of 75% can be modified to reflect the requirements of this section. The key phrase being "as nearly as is reasonably practicable". In this case the enhancements that have been identified, i.e the pressurisation system and high reliability sprinklers are achievable. Therefore in this instance, I see no reason to use a lower criteria as means of applying section 112. In other words, the target margin remains as 75% which is that required for a new building to met the requirements of the Building Code.

7.2.7 As discussed in paragraph 5.9.1.1, the design as proposed by the applicant has a margin of 1%. Clearly this is not acceptable. However, the expert has analysed the case of an AS 1668.1 compliant design (base case), along with sprinkler enhancements. This provides a margin of 77% which I do consider acceptable.

7.2.8 On balance on this case, I believe that the buildings design is sufficient in this regard, but that the same inspection and testing regime should be applied as in Determination 2005/109.

7.2.9 Accordingly, I find that I do have reasonable grounds on which to decide that the subject building as modified, whilst adopting a different fire safety concept than that used by the corresponding Acceptable Solution C/AS1, does achieve an equivalent standard of code compliance, and meets the fire escape requirements of Clause 112 of the Building Act 2004

7.2.10 The expert has also commented that the doors are not to be locked from the stairway side in manner that would prevent occupants from being able to enter any floor level from the stairway in fire alarm conditions. This, in effect, enables a "safe refuge" concept as an enhancement feature to be added to the basic fire safety design already evaluated, thereby contributing to the overall robustness of the design.

8 Ongoing Compliance

8.1 As noted in 7.2.4, the pressurisation system is critical to the overall effectiveness of the fire safety systems in the building. Accordingly it is important that the system be maintained and monitored to a high standard. For this to occur, the compliance schedule needs to include a specific requirement for on-going testing of the system. Determination 2005/109 provides a useful template for an appropriate schedule. I do not expect that the inspections, maintenance standard, person responsible and additional requirements will be to a lower standard than applied in that case.

8.2 As noted in 7.2.10, the expert also recommended a condition be included that the doors are not be locked from the stairway side in manner that would prevent occupants from being able to enter any floor level from the stairway in fire alarm conditions. This is an important feature that needs to be carried through in the detail design of the building systems, consequential commissioning and inclusion in the compliance schedule to ensure testing in the building warrant of fitness checks.

8.3 The foregoing analysis is based on the applicant's proposed future use of the building for SR-type activities. For avoidance of doubt, I record that I would also have concerns should the owner (in the future) consider changing the type of activity for the building.

9 Conclusion

9.1 I consider that the building's design, for SR-type activities, as modified and as supported by the analysis included in the experts' report, establishes to my satisfaction that the alternative solution for the apartments with a single means of escape from fire complies with clauses C2 and C3 of the Building Code.

9.2 It is emphasised that each Determination is conducted on a case-by-case basis. Accordingly, the fact that a particular design or system has been established as being code compliant in relation to a particular building does not necessarily mean that the same system will be code compliant in another situation.

10 The decision

10.1 In accordance with section 188 of the Act;

(a) I determine that the building complies with clause C2 of the Building Code subject to the following conditions:

(i) The sprinkler system water supply is to be a Class A supply, that is a primary tank with a secondary town mains supply, with dual pump sets. Complete and unambiguous plans and specifications are to be supplied to the satisfaction of the territorial authority

(ii) A stairway pressurisation system is to be designed, installed and commissioned in accordance with the Standard AS 1668.1:1998. Plans and specifications are to be supplied to the satisfaction of the territorial authority. The system is to be commissioned to the satisfaction of the said authority.

(iii) The fire engineer is to monitor construction to a high degree and provide a "Producer Statement of Construction Review" to the satisfaction of the territorial authority.

(iv) Doors are not to be locked from the stairway side in a manner that would prevent occupants from being able to enter any floor level from the stairway in fire alarm conditions.

(v) The compliance schedule for the building shall define escape route compliance, and the performance and monitoring standards. In addition, I take note of the Fire Service's recommendation that the compliance schedule should include an appropriate testing and inspection regime complying with relevant standards for all active systems, to ensure the ongoing compliance of the building.

(b) I instruct the territorial authority to issue a building consent for the addition of the penthouse apartments.

(c) I require the territorial authority to provide me with a report within two months of issuing the compliance schedule giving confirmation that these conditions have been met.

10.2 I also require the territorial authority to provide me with a report within two months should the owner propose that any of the "SA-type" activities be proposed within the building.

Signed for and on behalf of the Chief Executive of the Department of Building and Housing on 19 May 2005.

John Gardiner
Determinations Manager