Safety Case Assessment Guide: Predictive Aspects

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20th Oct 2016

MINISTRY OF MANPOWER

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Predictive Aspects – Outline

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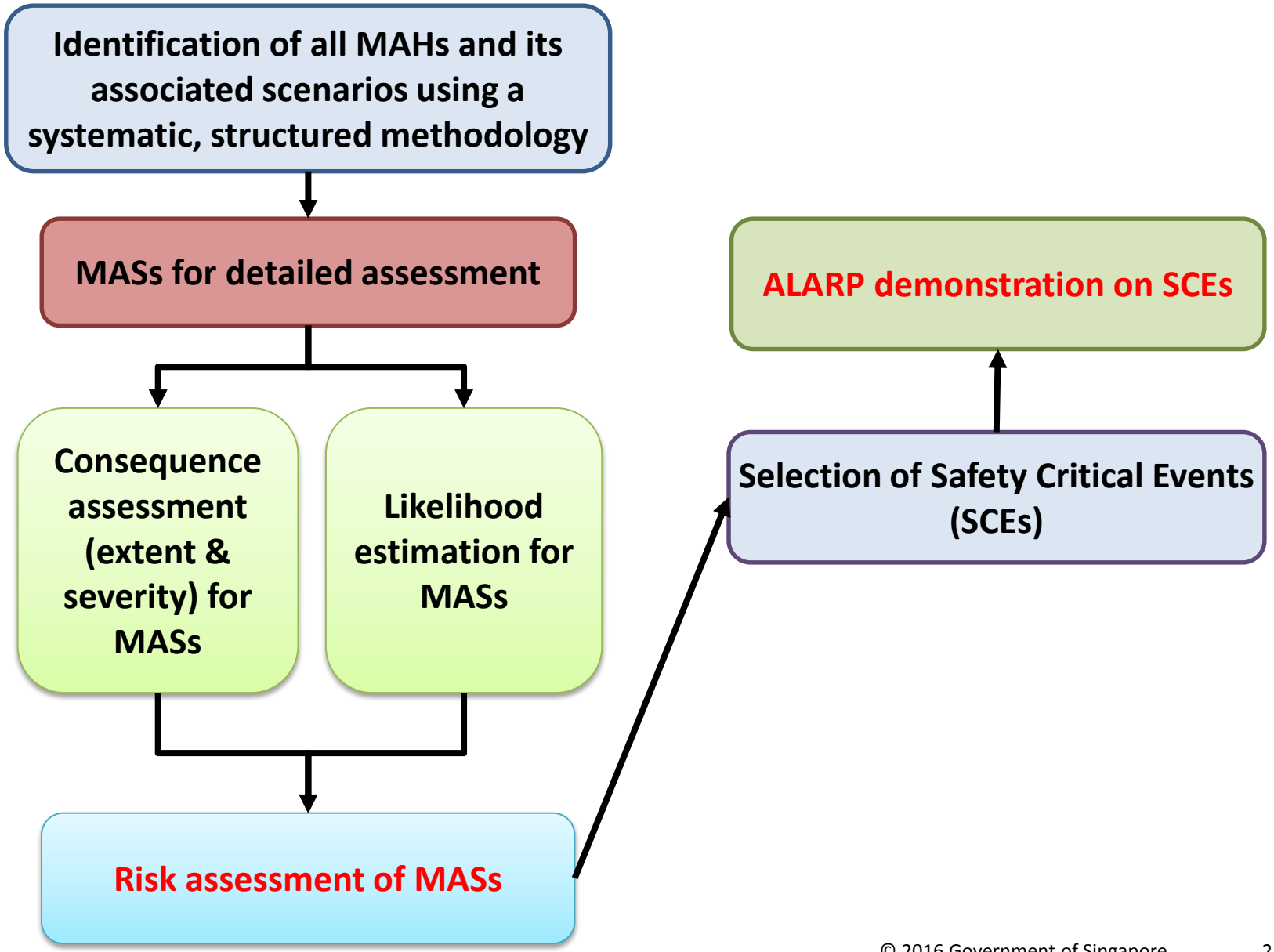
Getting Started: Definitions

- **Major Accident Hazards** – any hazard with the potential to lead to or escalate to a major accident (e.g. bulk LPG storage)

- **Major Accident Scenario** – circumstances that could lead to major accident (e.g. loss of containment of LPG storage tank)

- **Major Accident** – means any occurrence (including a major emission, fire or explosion) resulting from uncontrolled developments in the course of the operation of any MHI involving any dangerous substance, leading to serious danger to the health and safety of any person within or outside the MHI (e.g. VCE, BLEVE, jet fire, flash fire, pool fire, toxic release etc).

Predictive Aspects : Overview



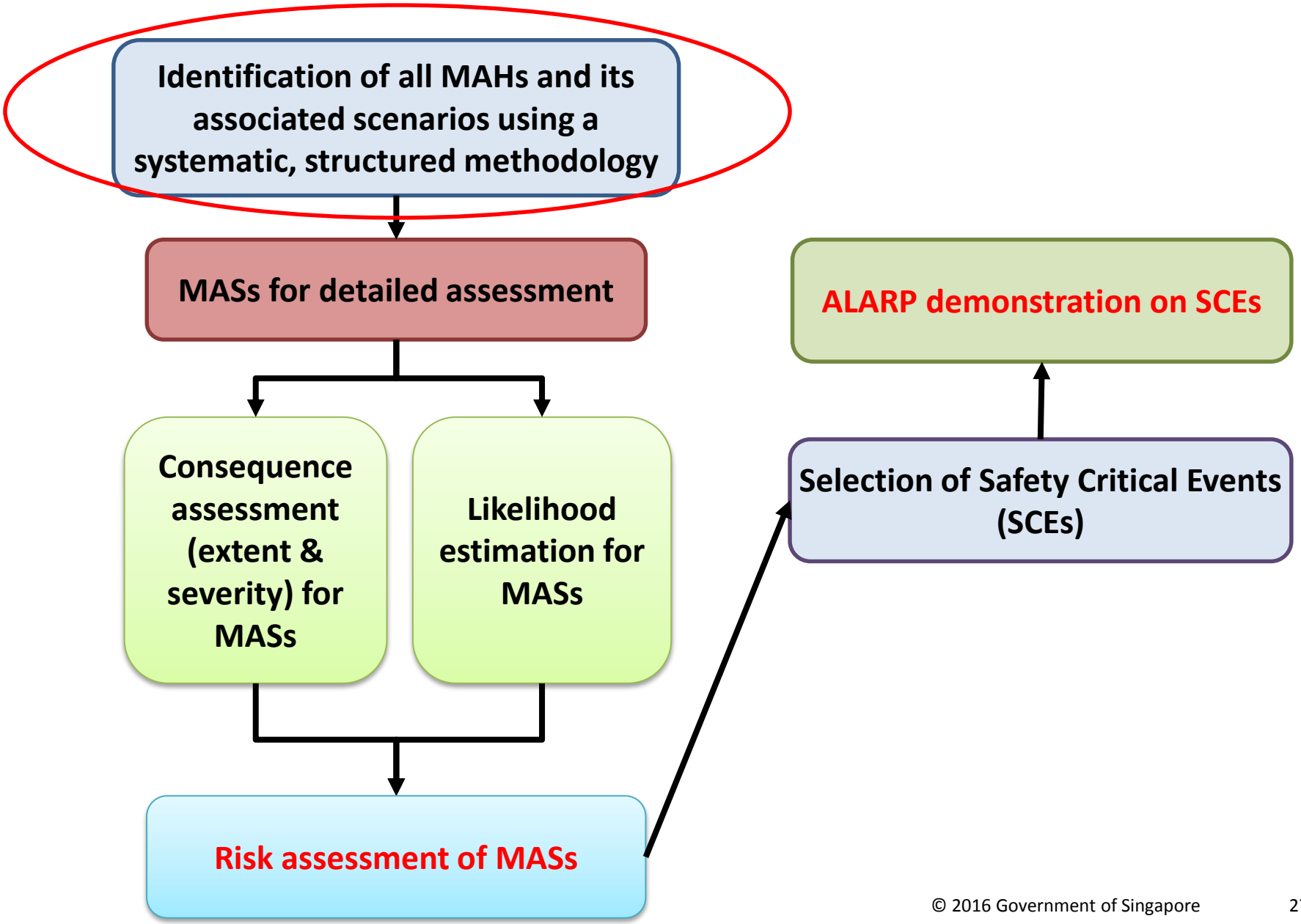
Predictive Aspects : Criteria

S/N	Technical Criterion
4.1	Describe the sections of the installation that could give rise to major accidents.
4.2	Identify and describe in detail all potential MASs
4.2.1	Demonstrate that a systematic process has been used to identify events and events combinations which could cause MAHs to be realised.
4.2.2	Suitable review of past accidents and incidents relevant to the site.
4.3	Describe a representative and sufficient set of MASs for the purpose of detailed assessment.
4.3.1	Any criteria for eliminating possible MASs from further consideration shall be clearly presented and well argued in the safety case.
4.4	Justify on the risk assessment methodologies used when conducting detailed assessment on the representative set of MASs.

Predictive Aspects : Criterion

S/N	Technical Criterion
4.5	Human factors have been taken into account in the risk assessment.
4.6	Adequate assessment of the extent and severity of the consequences for representative set of identified MASs
4.7	Estimates of the probability, in qualitative or quantitative terms, of each MAS analysed. This include a summary of the initiating events and event sequences (operational, internal or external) which may play a role in triggering each MAS.
4.7.1	Methods used to generate event sequences, and to estimate the probabilities of potential major accidents, shall be appropriate and used correctly.
4.7.2	Estimates of, or assumptions made about, the reliability of protective systems and the times for operators to respond and isolate LOC accidents or others need to be realistic and adequately justified.
4.8	Describe how MHIs uses risk assessment to identify the SCEs from the representative set of MASs for the purpose of ALARP demonstration.

Predictive Aspects : Overview



Identifying Major Accident Scenarios (MASs)

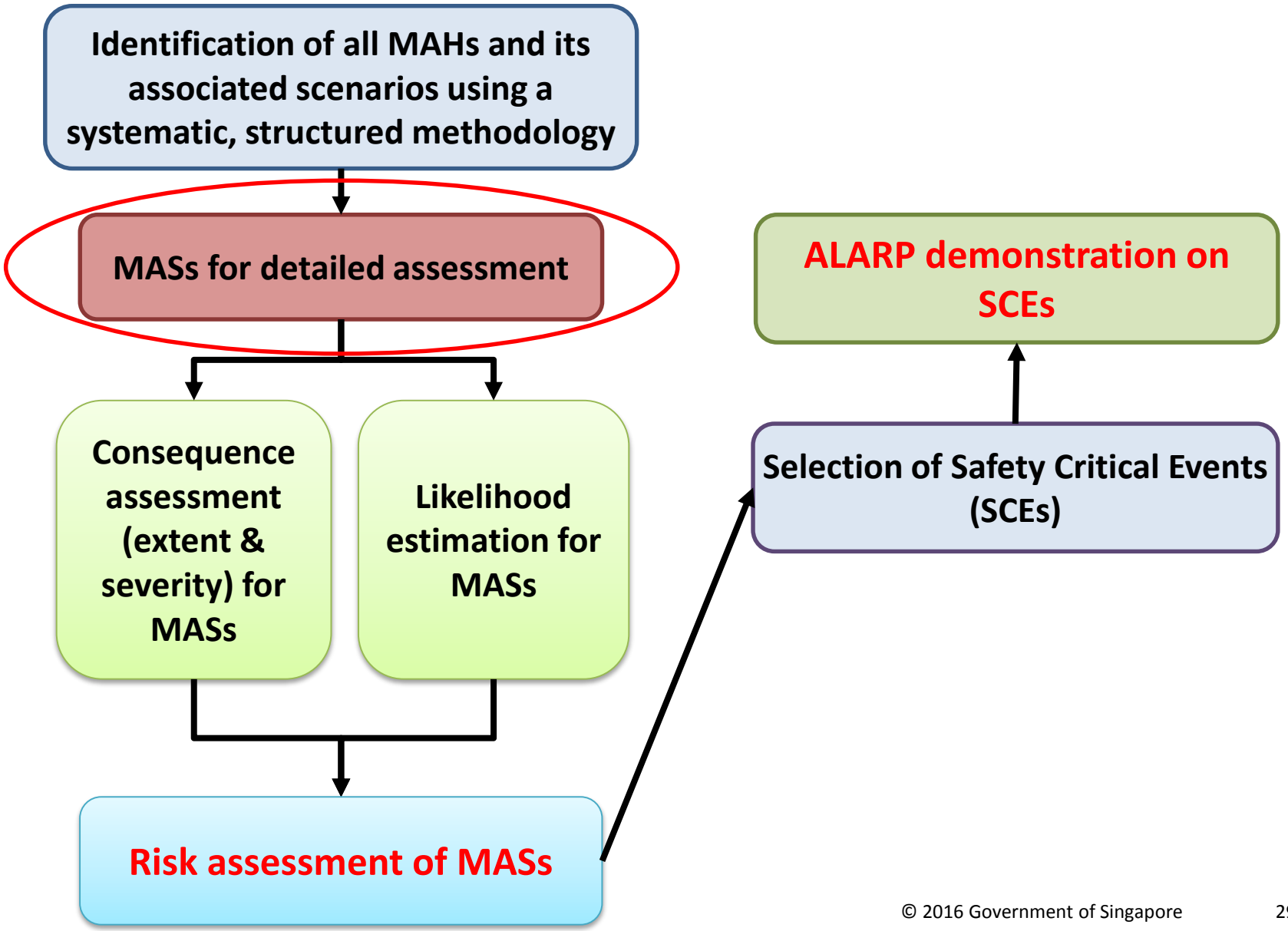
To meet criterion 4.2 and its sub criterion:

1. Demonstrate that a systematic process has been used to identify initiating events and event combinations which could cause MAH to be realised into MAS

2. Consider the following as causes or initiators of potential MAS during identification process (list not exclusive):

- **Operational causes** like exceeding process parameters limits, equipment failures , human errors etc
- **Internal causes**, where relevant like fires, explosions or releases of dangerous substances
- **External causes**, where relevant, impacts of accidents (e.g. fires, explosions, toxic releases) from neighbouring installations (domino effects)
- **Learnings from past accidents and incidents** at site and other similar facilities

Predictive Aspects of SC: Overview



Representative Set of MASs

To meet criterion 4.3:

1. Select a subset of MASs, known as representative set of MASs, for complex MHIs. For less complex MHIs or if the number of MASs identified are limited, all MASs identified should be considered for detailed assessment.

2. Ensure representative set of MASs are sufficient and should include:

- ✓ Different hazards, substances, processes
- ✓ Worst case scenarios should be included
- ✓ Lesser consequence scenarios at higher frequency
- ✓ Events which in themselves might be low risk, but which could escalate to give a more serious event
- ✓ Less severe scenarios should be represented by the most severe scenarios (of similar nature) rather than being eliminated

Detailed Assessment on Representative Set of MASs

To meet criterion 4.4:

1. Justify risk assessment methodology based on
   - ✓ expertise and competence of those identifying and analysing hazards;
   - ✓ methods used in the risk analysis;
   - ✓ data and assumptions; and
   - ✓ how the significance of the risk was assessed.

2. MASs which have a higher level of risk, consequences impact or potential for escalation to a more serious event shall be conferred with a greater degree of rigour during the assessment process

3. Justify in the safety case on the depth of analysis and degree of rigour required for each representative set of MASs prior to the detailed assessment

Proportionality Principle

Proportionality relates to the depth of analysis and degree of rigour required in your risk assessment

Key factors in determining proportionality, from MHD's perspective:

- ✓ worst case severity (i.e. how many fatalities)
- ✓ whether individual risk close to intolerable criterion
- ✓ other qualitative factors (i.e. scale/nature/properties of hazards, proximity to populations, escalation potential)

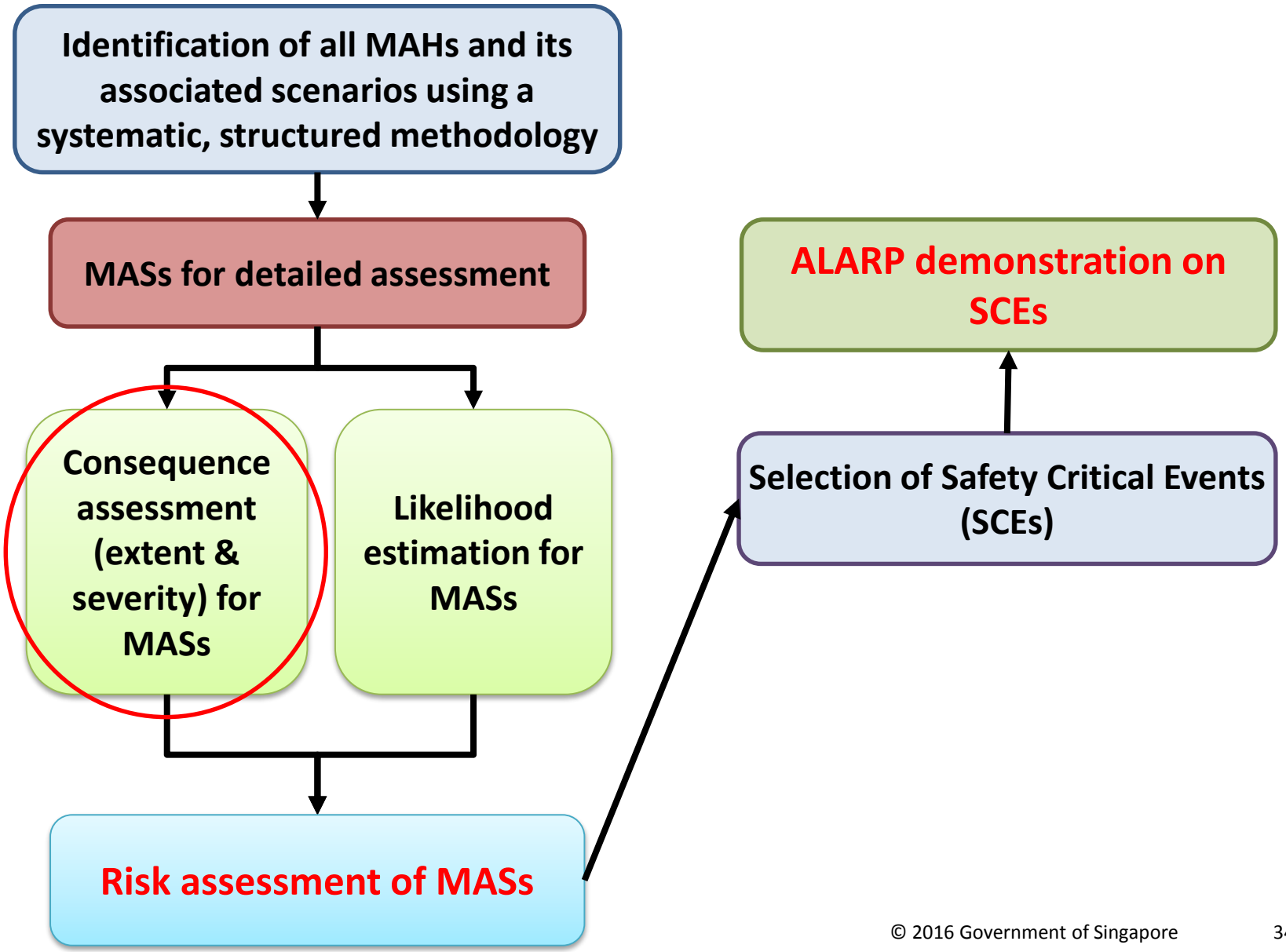
Human Factors in Risk Assessment

To meet criterion 4.5:

1. Show a systematic process for identification of human failures, actions or other involvement as contributors to major accident and how they can lead to major accident initiation or escalation. This has to be integrated with the overall risk assessment.

2. Where quantitative assessments are used:
   (i) address the probabilities of human actions and omissions;
   (ii) address the reliability of measures which is dependent upon human action; and
   (iii) show that all assumptions made in the determination of human failure probabilities are based on a thorough and systematic assessment

Predictive Aspects of SC: Overview



Consequence Assessment

To meet criterion 4.6:

1. Present extent information:
   - ✓ Consequence distances of the major accidents on geographical maps

2. Presents severity information:
   - ✓ Numbers of potential fatalities, serious injuries, hospitalisations
   - ✓ Consequences banding range (e.g. 1-5 fatalities, 5-20 fatalities, 20-100 fatalities, etc)
   - ✓ Where major accidents have been put into example groups, then it is acceptable to present extent and severity for each group

Consequence Assessment

To meet criterion 4.6:

3. MHIs shall either describe, justify or reference:
   - ✓ Consequence assessment model used;
   - ✓ Limits of applicability of the model used; and
   - ✓ Assumptions made and the values used in the model

4. Any harm footprints, levels or vulnerability models used, in predicting the extent of areas where people or the vicinities may be affected shall be aligned to the Revised QRA Guidelines.

http://www.nea.gov.sg/anti-pollution-radiation-protection/central-building-planning

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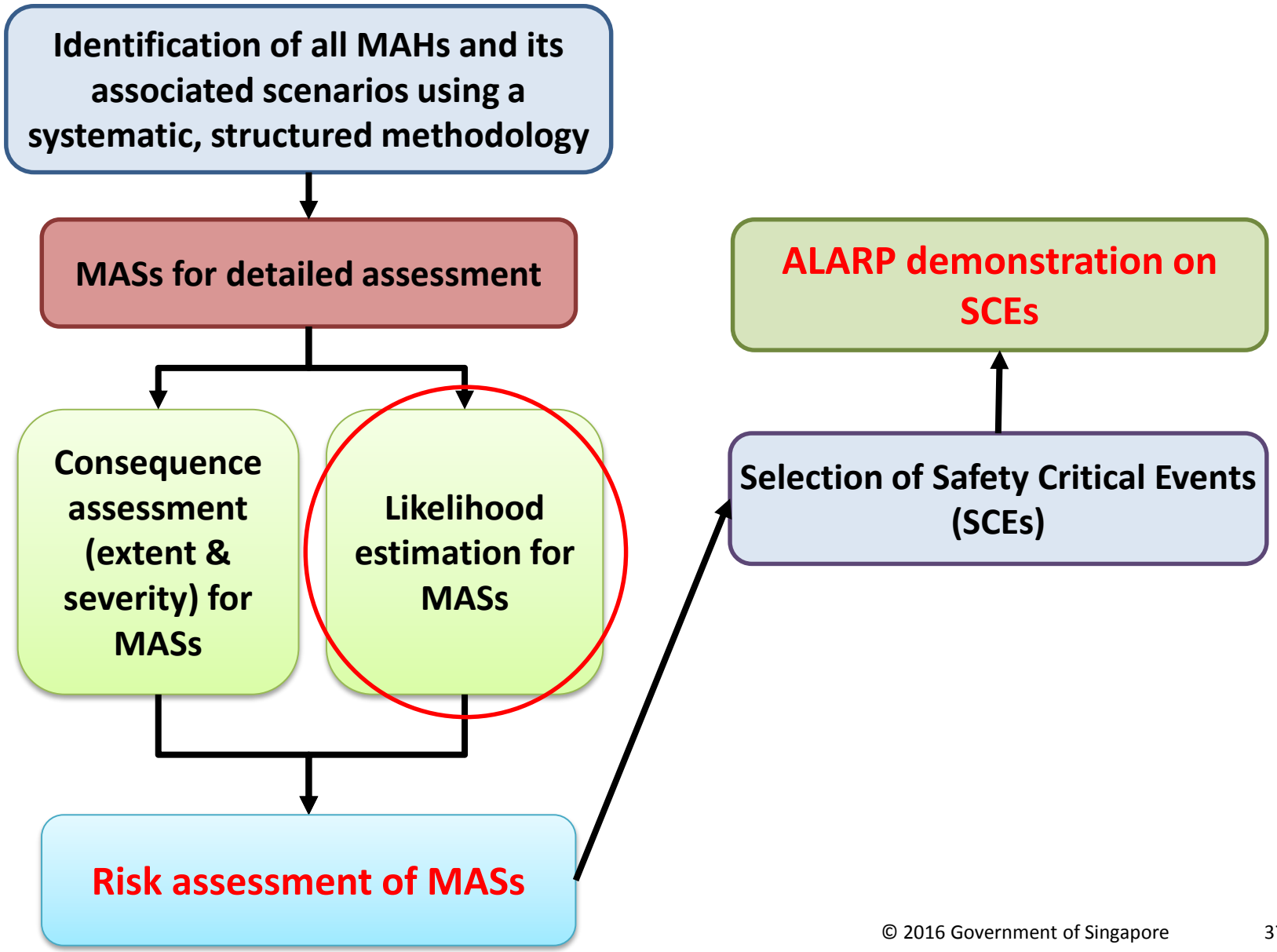


Likelihood Estimation

To meet criterion 4.7 and its sub-criterion:

1. Generate event sequences and estimation of probabilities of potential major accidents

- ✓ relevant operational and historical failure data
- ✓ fault tree analysis (FTA)
- ✓ event tree analysis (ETA) or
- ✓ other relevant methodologies

2. For historical failure rates:

- ✓ Ensure that failure rate data used are aligned to the revised QRA Guidelines
- ✓ Include the references and methods of derivation (where appropriate) for using failure rate data not in accordance with the Revised QRA Guidelines

Likelihood Estimation

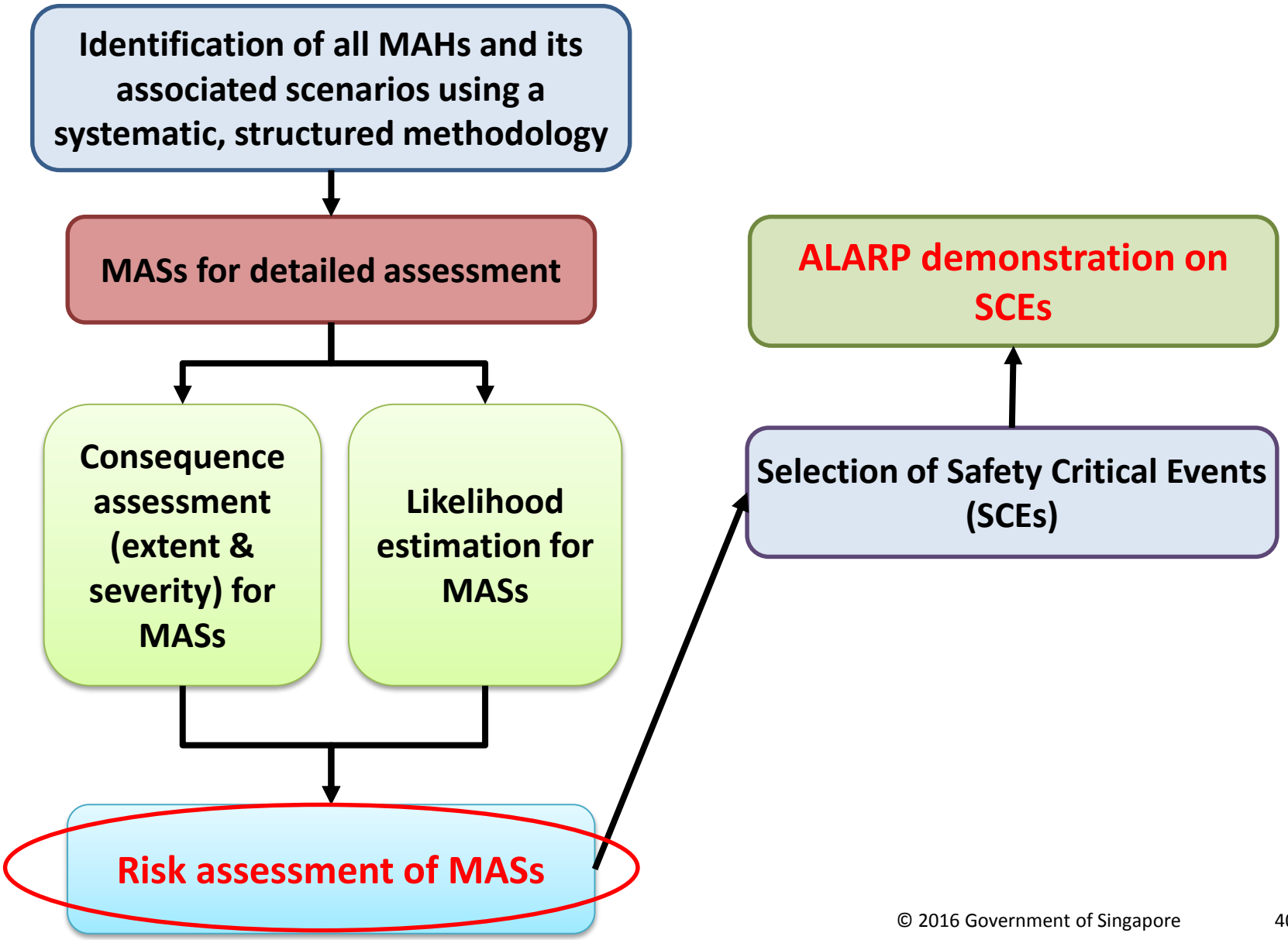
To meet criterion 4.7 and its sub-criterion:

3. The qualitative or quantitative arguments presented in the safety case shall be realistic, well-reasoned and plausible. Where possible, arguments shall be backed-up by credible performance data.

4. Any qualitative arguments made shall be:

- ✓ based on accepted good standards for engineering and safe systems of work; and/or
- ✓ supported by evidence on the likely demand on the various control measures and systems, and what the consequences might be if these fail.

Predictive Aspects of SC: Overview



Risk Assessment

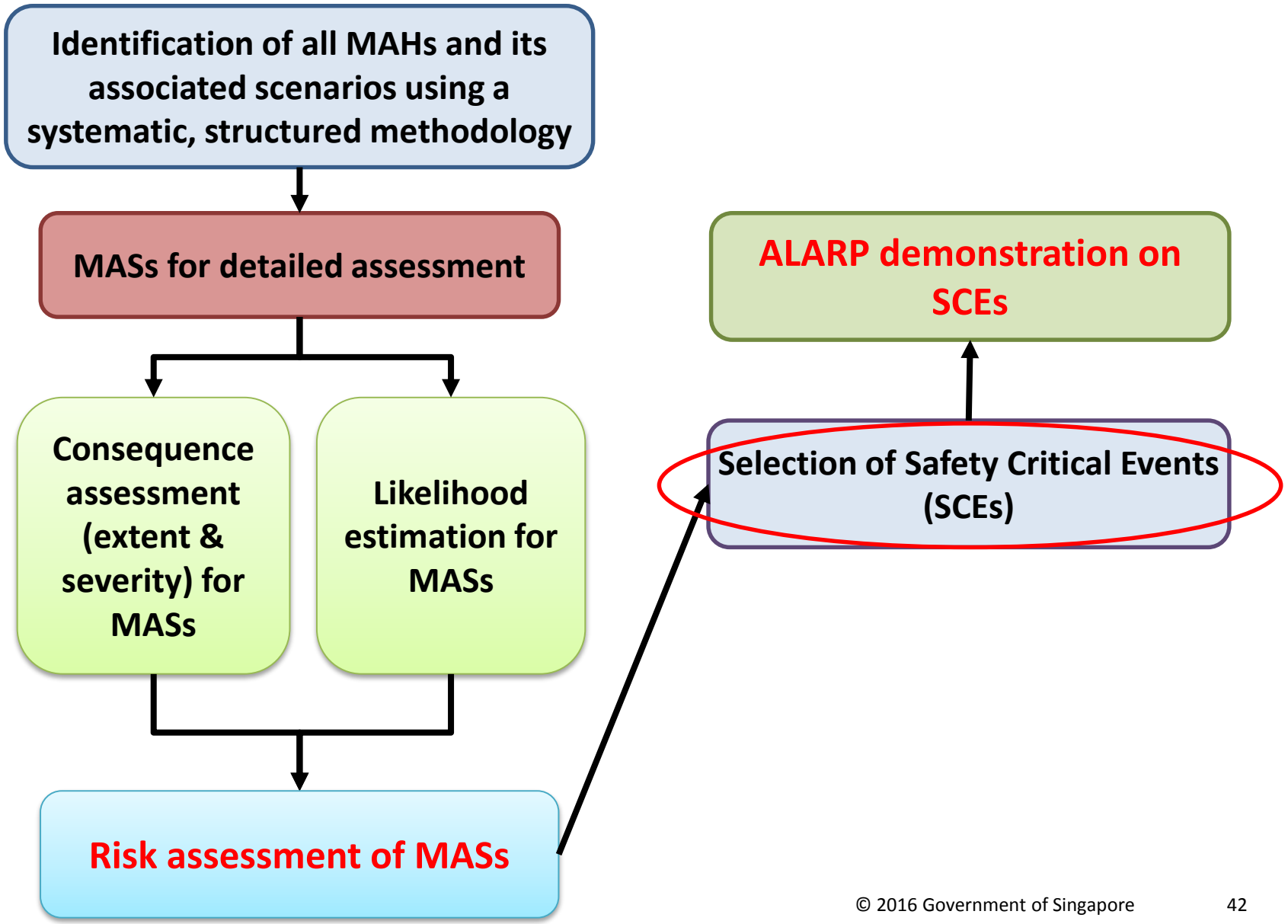
1. Draws together the likelihood and consequence assessments in an appropriate way to make estimates of the risks

2. Where major accidents have been put into example groups, the frequencies of all the major accidents within the group is taken into account

Risk Profile/Picture

Proportionality of MHI

Predictive Aspects of SC: Overview



SCEs Selection

To meet criterion 4.8:

1. Show which events are critical from a safety point of view and this requires consideration of the likelihood and consequences of the various MASs.

2. Identify SCEs and the basis for the choice of the identification. SCEs are those that dominate the risk contribution at different distances and critical in identifying suitable risk reduction measures for ALARP demonstration.

3. One way to identify potential SCEs is by using risk matrix:

- All events in the most severe consequence band (including worst case scenarios)
- Highest frequency events within each consequence banding

Example: LOC from LPG Storage Tank

MAH:
LPG- Highly flammable light hydrocarbon with low flash point

MAS:
1.Catastrophic failure of LPG tank (*QRA study*)
2.Cold catastrophic failure of tank (*HAZOP, Human Error)*
3.LOC due to vessel overfill/ overpressure (*HAZOP*)
4.LOC due to wall corrosion (*HAZOP*)
5.LOC during water draining activity from tank (*HAZOP, Human Error, Feyzin accident*)

Representative Set Of MAS:
1.Catastrophic failure of LPG tank (MAS-1,2…)
2.LOC of LPG (small leak (MAS-3,4…)
3.LOC from 2" drain valve (MAS- 5….

Detailed Risk Assessment

Selected SCEs
•Catastrophic failure of LPG tank
•LOC from 2" drain valve

Common Pitfalls in Predictive Aspects

- Failure to consider high consequence low probability accident scenarios. These scenarios are often dismissed on the basis of unjustified assumptions that such events were considered to be 'non credible‘

- Lack of justification and information about the effectiveness, availability and reliability of safety systems. Consequence analysis based on assumptions that safety control and intervention measures (i.e. automatic shut down systems) would always work effectively and not fail ‘on demand’

- Limited description and/or evaluation of escalation potential (on-site) and domino effects (off-site)

Common Pitfalls in Predictive Aspects

- Process related scenarios (i.e. overfilling, runaway reaction) are often unjustifiably omitted for consequence and likelihood assessment

- The selection of unidentified and sometimes inappropriate mathematical models (i.e. source terms, dispersion and vulnerability) for which their limitations and assumptions were not transparent

- Companies had large volumes of detailed information (i.e. from quantitative risk assessment) available to cover the predictive aspects, but did not present this adequately in their safety cases

Thank You!