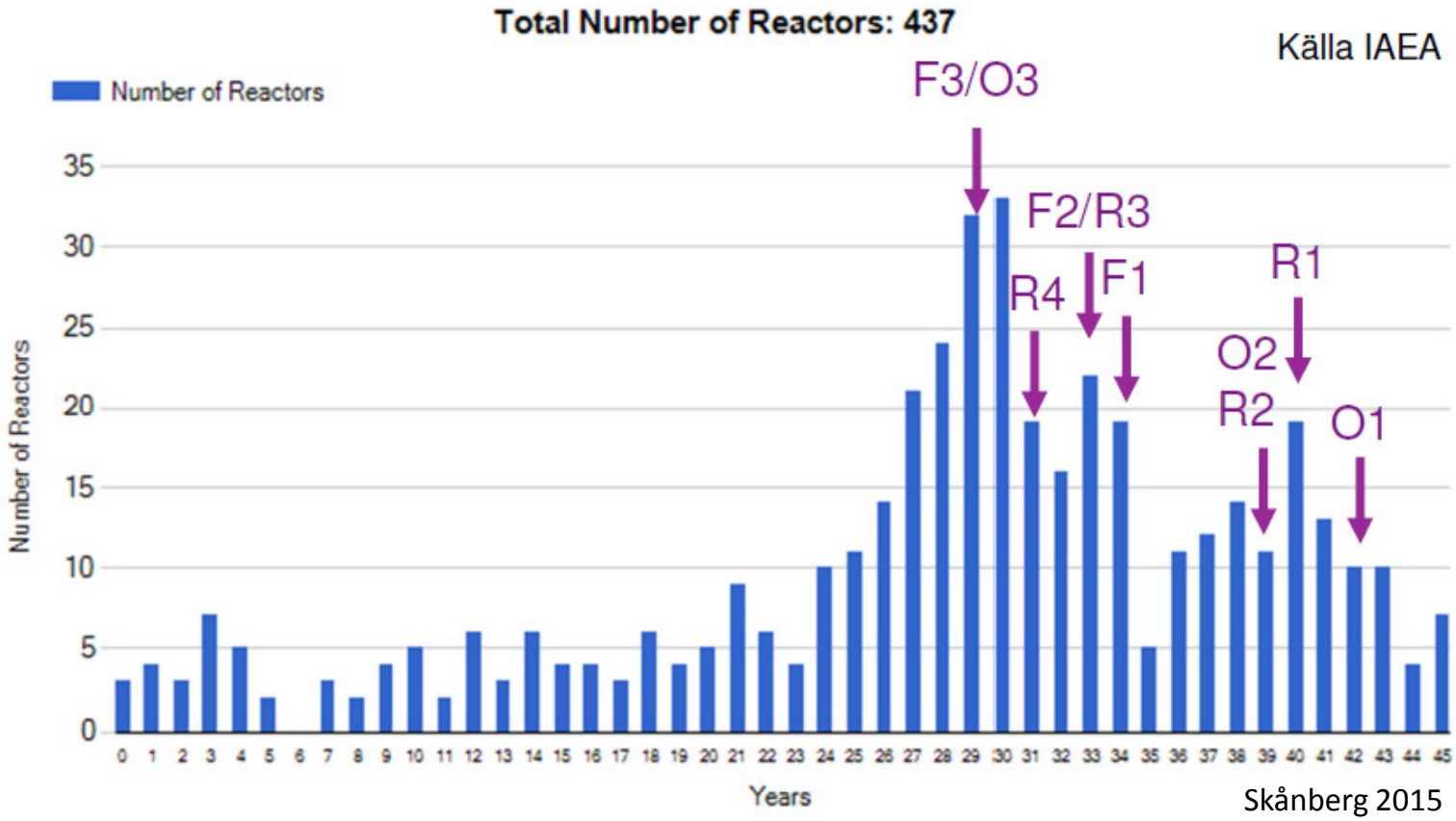
Monitoring and instrumentation of concrete structures

Energiforsk seminar: Instrumentation and monitoring of concrete structures in nuclear power plants

Christian Bernstone, Vattenfall AB

Solna 15th March 2016

Age of Swedish NPPs



Skånberg 2015

Long-term operation for certain reactors potentially up to 60 years …

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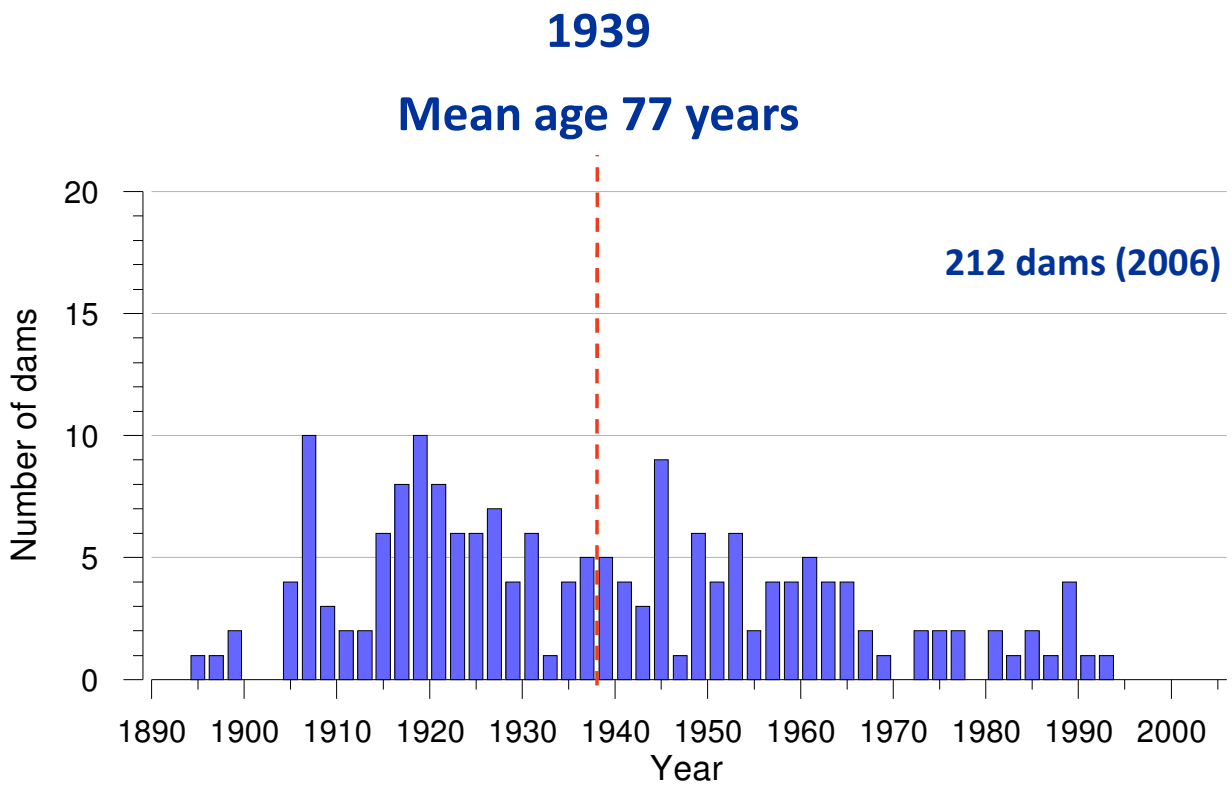
Age of Swedish concrete dams



… which we already are well beyond for our hydropower assets

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Energiforsk Nuclear power concrete structures R&D program

Strategy plan 2016-2018

The vision of the nuclear concrete research program is to ensure having civil works that support safe operation of NP throughout the life-length of the power plants, and to ensure that the license holders and the regulator stay well informed on civil works aspects of permits and LTO.

The primary receivers:

- License holder's departments and teams responsible for civil works design, maintenance and operation of nuclear power plants
- The regulator

The wider receiver group:

- Universities and institutes
- Service providers
- Stakeholder organisations

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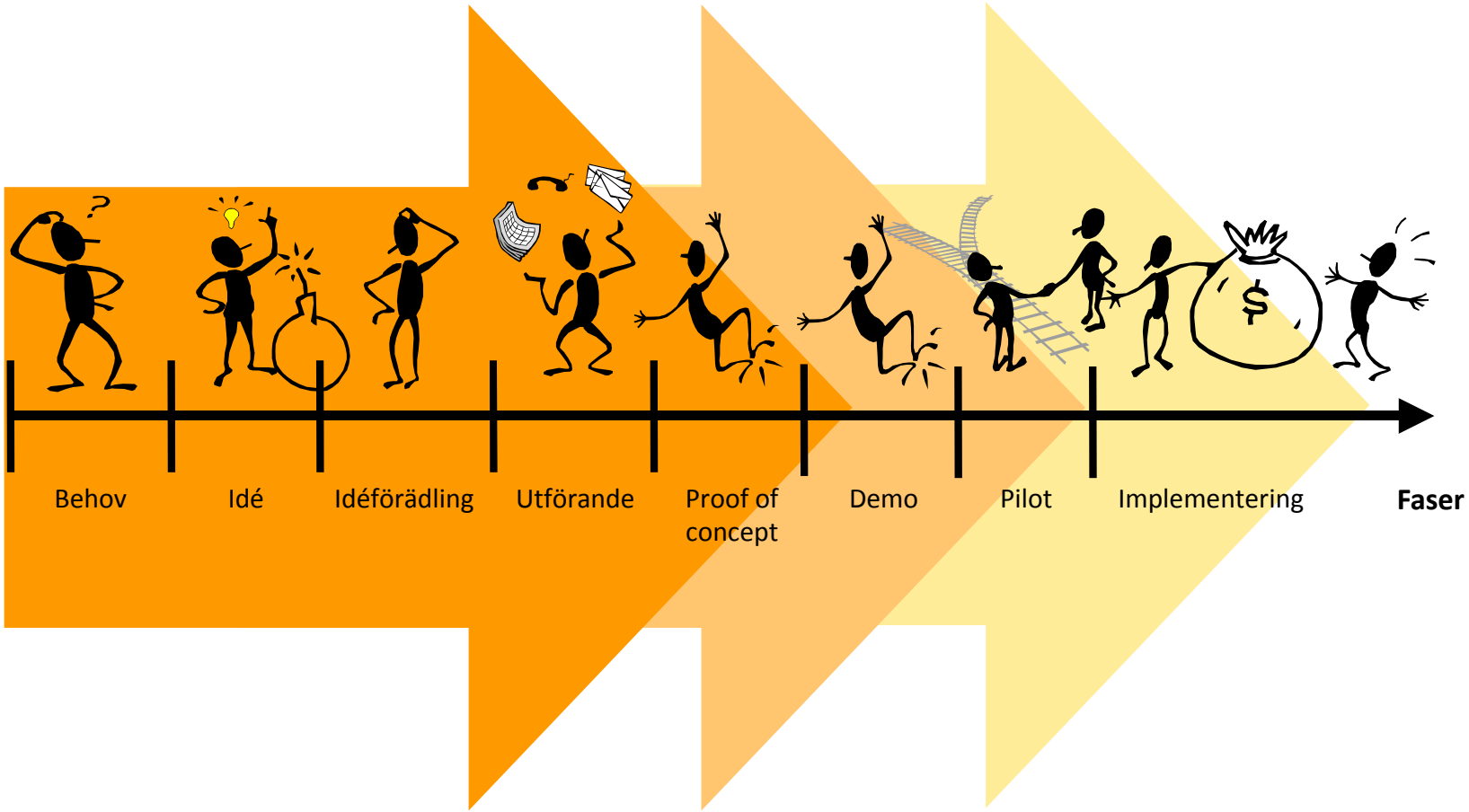
Focus areas of the strategy plan

- Focus areas based on an inventory of needs in 2015:
  1. Investigate local environments of reactor containments that could cause degradation affecting its leak-tightness
  2. Develop tools for the assessment of RC pre-stressed tendons and liners
  3. Validity of advanced calculation tools applied to RC
  4. Investigate specific safety issues of cooling waterways
- One topic of today specific activity:
  - Condition monitoring of nuclear concrete structures
  - Input to our planning process
  - Work will commence this year and continue to 2018

Proof-of-concept

- Supporting the licence holders future implementation



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Hierarchy of requirements

1. Mandatory

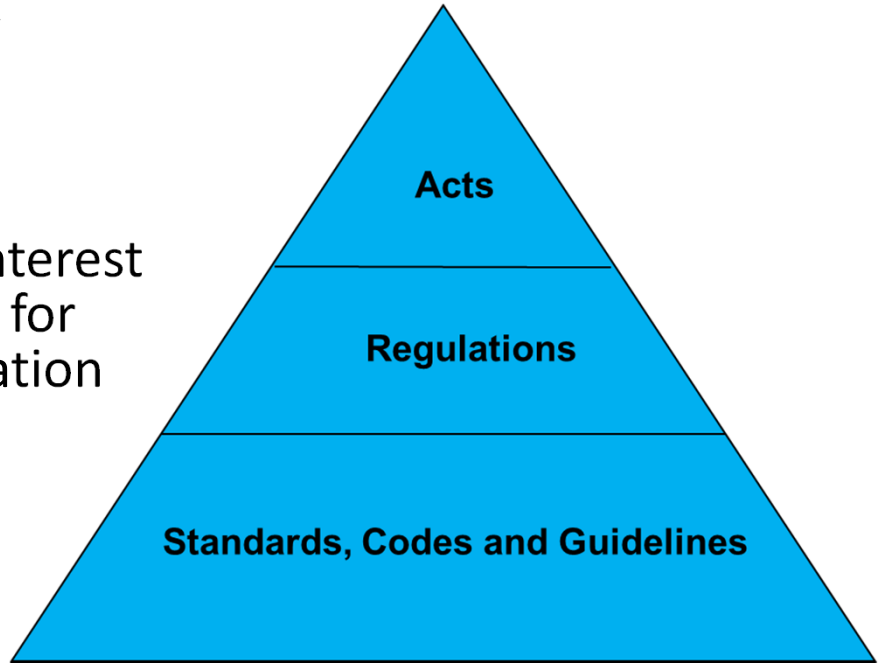
   Sources of requirements that are legally binding to a licensee in Sweden, e.g. SSM Regulations (white pages), IAEA Safety Fundamentals and Safety Requirements.

2. Guidance

   Guidance for national sources and international regulations, e.g. SSMFS General Advice (yellow pages) and IAEA Safety Guides

3. Guidance

   International standards and other sources of interest which is used to define the complete guidance for design, construction, commissioning and operation



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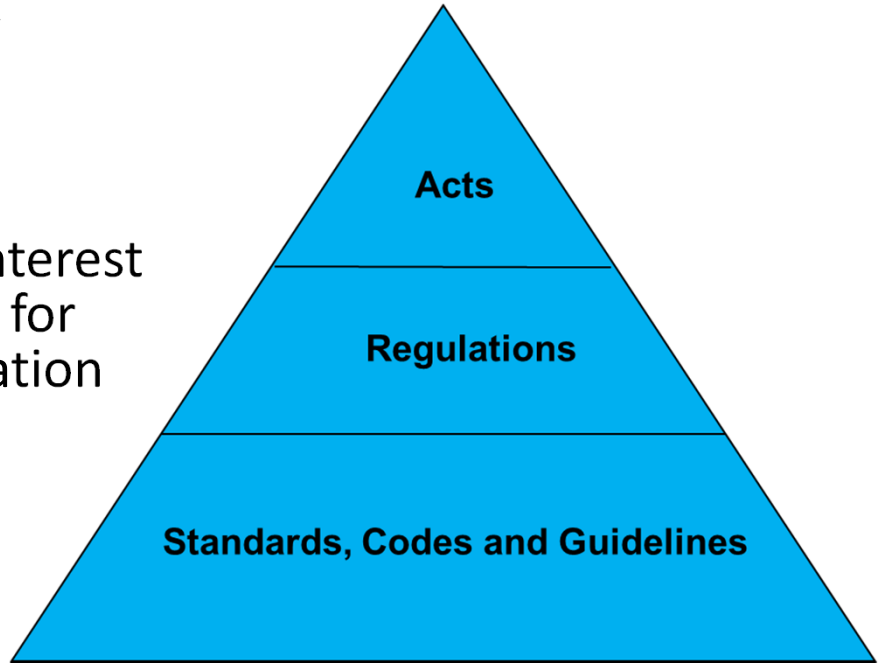
Has led to certain monitoring activities today, e.g. containment air tests and periodic testing of pre-stressed tendons



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Hierarchy of requirements

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Currently reviewed

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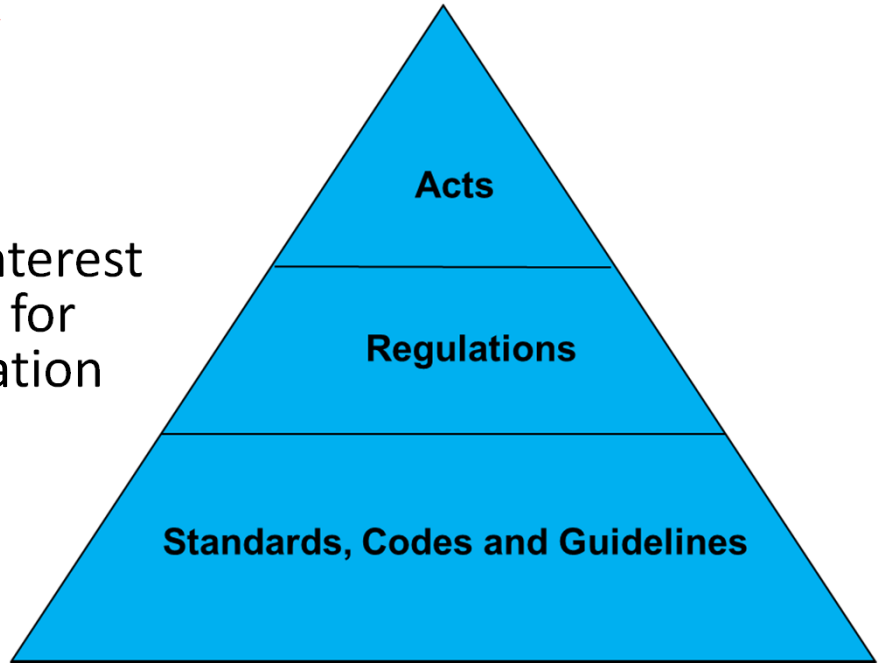

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Long-term operation

- IAEA

  Operation beyond an established time frame set forth by, for example, license terms, design, standards license and/or regulations, which has been justified by safety assessment, with consideration given to life limiting processes and features of systems, structures and components

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Examination LTO conditions in Sweden

- Through a Periodic Safety Review process focussing on LTO
- According to SSM it must be shown that the plant with its different structures, systems, and components
  - i.e., building structures, mechanical components, electrical equipment, instrumentation and control equipment
- can be used / operated beyond the time and with the assumptions which were made when designing them
  - including revalidations of design analyses, other verifying analyses (TLAA) and environmental qualifications for the extended period
  - and that there are no degradation and deterioration of various types
- or make the necessary replacements

Source: Skånberg 2015

Examples of LTO highlighting issues by SSM

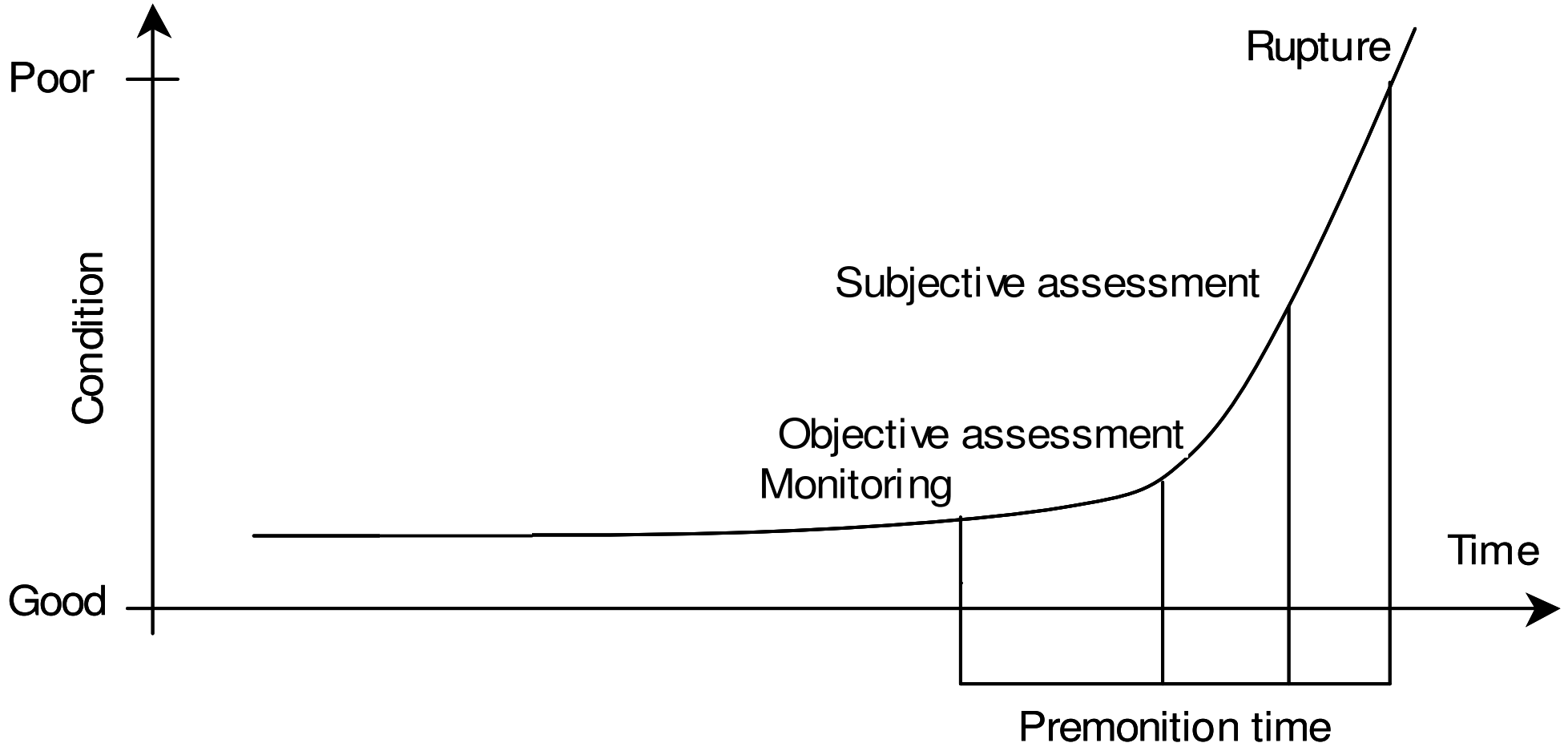
- … prior to and during long-term operation special attention needs to be given to:
  - Irradiation embrittlement of reactor pressure vessels, taking account of effects that may substantially increase the rate of embrittlement
  - Fatigue, taking account of impact from the reactor water environment on areas sensitive to fatigue
  - The condition of tendons and steel liners in reactor containments
  - Degradation mechanisms that can influence reactor containments' concrete and metal parts
  - Possibilities for reliable inspections and testing of reactor containments
  - The validity of environmental qualifications of electrical, instrumentation and control equipment as well as parts with polymer construction materials

Source: Skånberg 2015

Data management in relation to operation and maintenance

- There are two parallel categories of information going in and out of the power plant:
  - Primary information relating to operation, directly linked to the control centre.
  - Secondary information relating to maintenance, to assess the condition of the power plant machinery, equipment etc.
- The high availability of energy production has a high priority:
  - Non-planned stops of the turbines shall not happen
  - Planned stops for maintenance work shall be few and of short duration
- These requirement are challenges for the maintenance organisation to handle, and the longer premonition times they can obtain on potential problems the better

Detection of faults from condition assessments



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The monitoring plan

- Goals of “Baseline” Monitoring Plan
  - To differentiate status of <xxx> before (new) and during operation (ageing)
  - To communicate
- How to establish a “baseline” monitoring plan
  - Identify the most critical locations to be monitored (risk assessment)
  - Evaluate different monitoring techniques
  - Include best practice approaches
- … but we generally do not have the baseline conditions
- … and we do generally not have historical data to build performance statistics from
- However, we do know the design basis
  - Needed for the design of control charts

Control charts

- Example from dam safety

Tillstånd	Beskrivning	Åtgärd
NORMAL – TILLSTÅND SOM FÖRVÄNTAT		
Normalnivå GRÖN	Observationer och mätningar indikerar förväntade och acceptabla värden	Fortsätt tillsyn, mätningar och underhållsprogram
VARSELNIVÅ – TILLSTÅND SOM AVVIKER FRÅN FÖRVÄNTAT TILLSTÅND		
Varselnivå GUL	En eller flera indikeringar är över förväntad nivå	Bekräfta tillförlitligheten Kontakta utvärderingsgrupp för att besluta om åtgärd Informera berörda parter om förhållandena och rekommendera planer för åtgärder Vidta åtgärder för att minska risken för att indikationerna kommer att överskrida larmnivåer
LARMNIVÅ – TILLSTÅND NÄR ÅTGÄRDER SKA VIDTAS		
Varningsnivå RÖD	En eller flera indikeringar är över larmnivån som upprättats för aktuella instrument	Informera alla parter om risker med att arbeta i påverkat område Genomför åtgärdsplanen Utveckla säkra steg att fortsätta

Source: Åke Nilsson 2014

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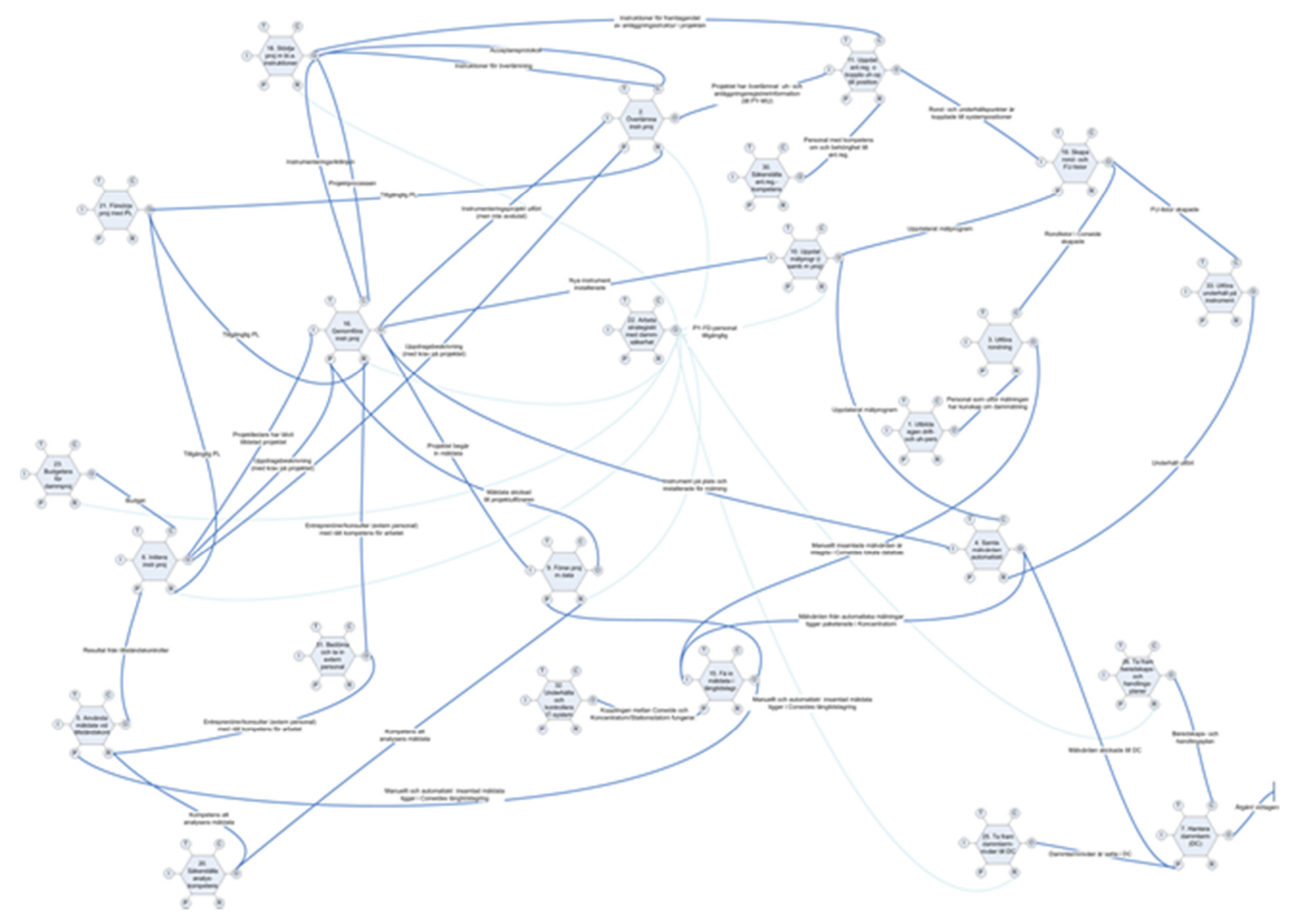
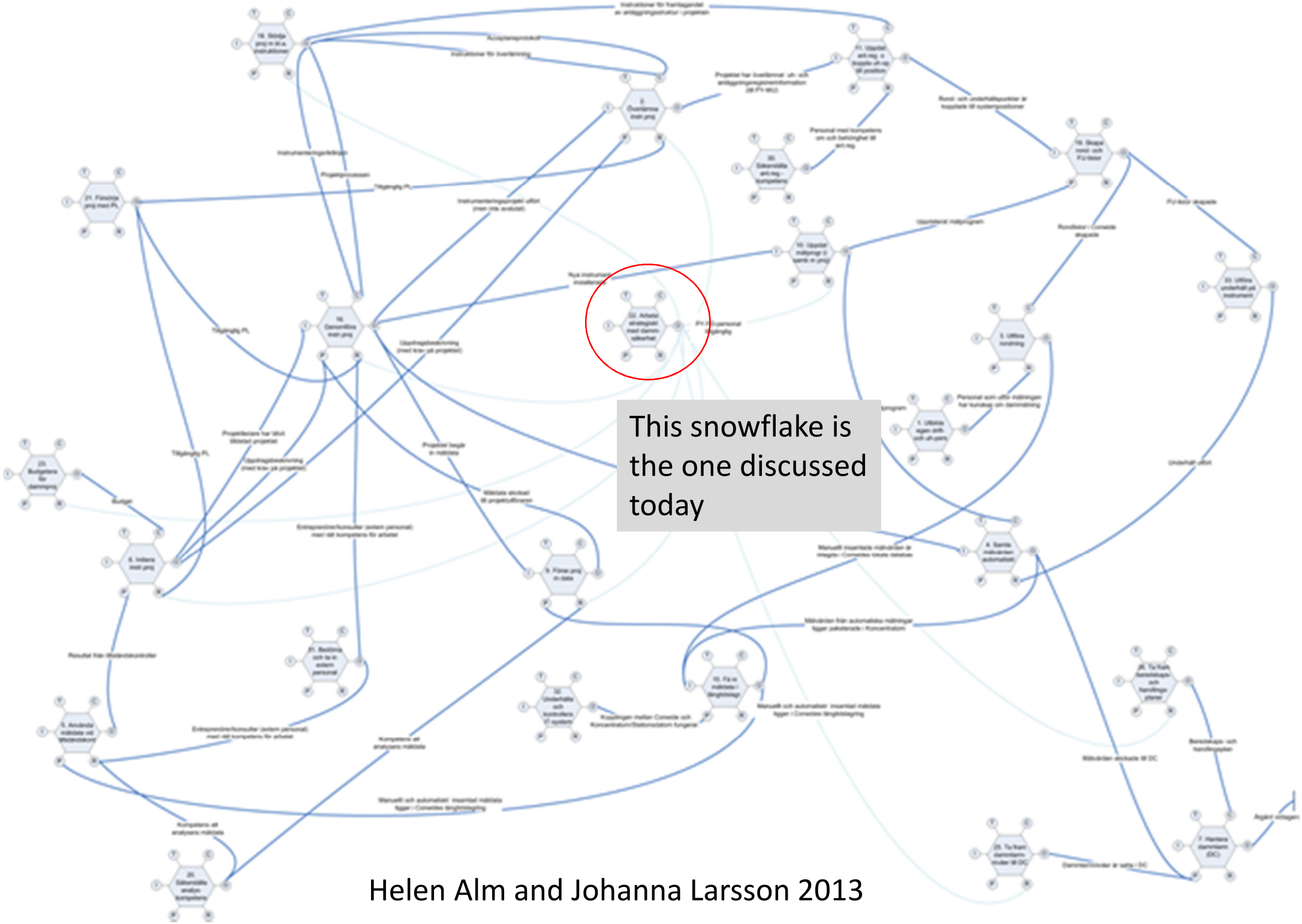
NPP functionalities supported by concrete structures

- Containment - multiple barriers against accidental release of radioactive materials
  - Presentations by Johan Klasson, Ulrik Brandin, Olli Tiirola, Manouchehr Hassanzadeh, Abdul H. Sheikh and Peter Lundqvist
- Provide cooling water and discharge it when used
  - Presentations by Bror Sederholm & Johan Ahlström, Peter Ulriksen, and Patrik Fröjd

Final remark

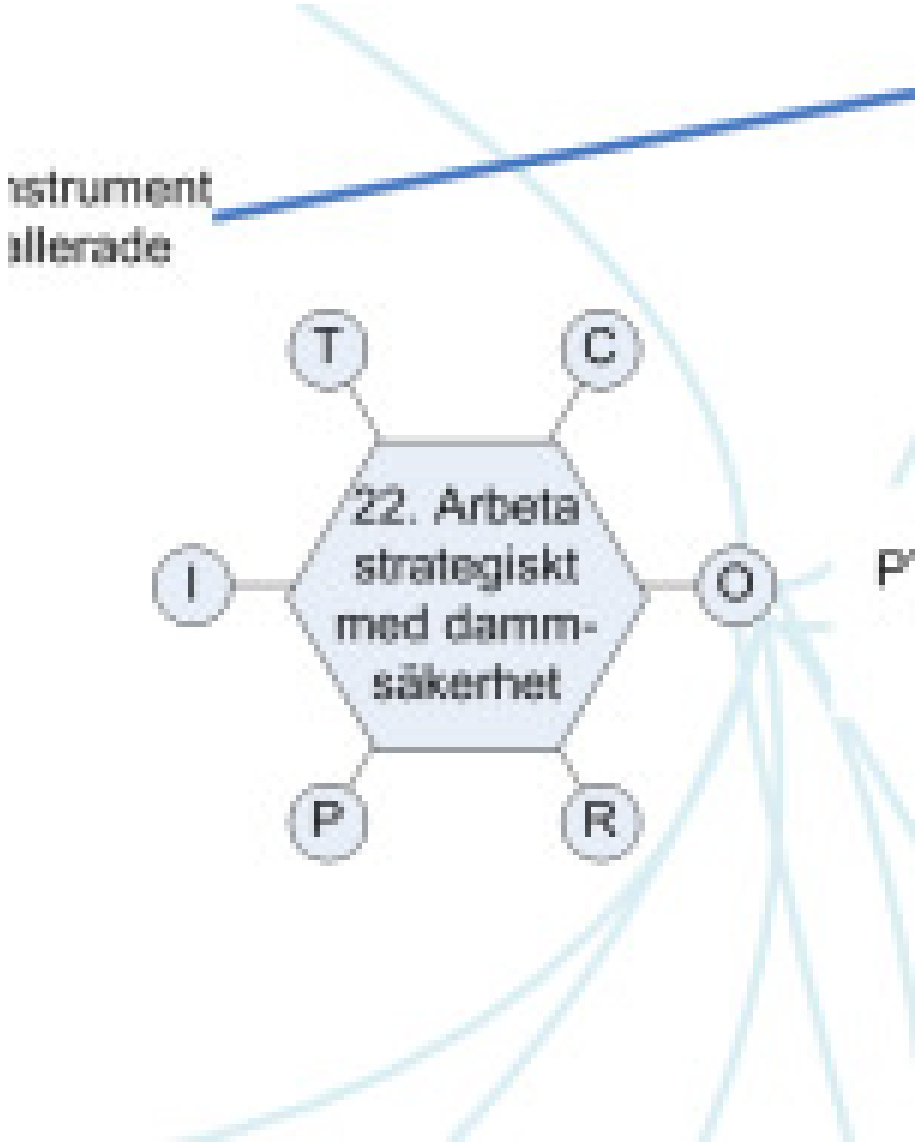
- Condition monitoring is not only technology
- Vattenfall BA Hydropower has mapped its dam safety monitoring process:
  - 26 work activities were identified using FRAM
  - Each activity can be described by six aspects: Time, control, precondition, resource, input and output
  - Illustration of complex interactions by snow-flake charts


Instruktioner för framtagandet av anläggningsstruktur i projektet
16. Ställa prog in till a produktionen
Acceptanceprotokoll
Instruktioner för överlämning
Projektet har överlämnat uh- och anläggningsregisterinformation (till PV-MU)
21. Upprätt anl.reg. o knoppla uh-cap till position
Rutin- och underhållspunkter är kopplade till systempositioner
2. Överlämna instr.prog
30. Säkerställa anl.reg.-kompetens
Personal med kompetens om och behörighet till anl.reg
18. Skapa rutin- och FU-listor
Instrumenteringsförteckningen
Projektprocessen
Tillgänglig PL
21. Förankra prog med PL
Instrumenteringsprojektet utförd (med rätta ansvariet)
10. Upprätt mätprogr o samla in prog
Upplateral mätprogram
Rondlistor i Comesite skapade
FU-listor skapade
23. Utföra underhåll på instrument
Nya instrument installerade
22. Arbetar strategiskt med damm-säkerhet
PV FU-personal tillgänglig
16. Genomföra instr.prog
Tillgänglig PL
Uppdragsbeskrivning (med krav på projektet)
3. Utföra rondrong
Upplateral mätprogram
Personal som utför mätningen har kunskap om dammbildning
1. Utbilda ägar- och drift- och uh-pers
Projektledaren har tillrut tillstånd projektet
Tillgänglig PL
Uppdragsbeskrivning (med krav på projektet)
Projektet begär in mätdata
Instrument på plats och installerade för mätning
Underhåll utfört
25. Budgetera för dammprog
Budget
8. Initiera instr.prog
Mätvärdena skickat till projektledaren
Entreprenörer/konsulter (extern personal) med rätt kompetens för arbetet
9. Förse prog m data
4. Samla mätvärden automatiskt
Manuellt insamlade mätvärden är integrerade i Comesites lokala databas
Mätvärden från automatiska mätningar lagras paketerade i Koncentratorn
Resultat från tillsynsbesöksrutiner
31. Beställning och tar in extern personal
Entreprenörer/konsulter (extern personal) med rätt kompetens för arbetet
32. Underhålla och konsultera IT-system
Kopplingen mellan Comesite och Koncentrator/Stationsdatorn fungerar
15. Fås in mätdata i lämplighetsgr
Manuellt och automatiskt insamlad mätdata lagras i Comesites lämplighetsgrupp
26. Tu-fram handlingsprogram och hanlingar planer
Beräkningar och handlingsplan
Mätvärden skickade till DC
5. Använda mätdata vid tillsynsbesök
Kompetens att analysera mätdata
Manuellt och automatiskt insamlad mätdata lagras i Comesites lämplighetsgrupp
Kompetens att analysera mätdata
20. Säkerställa analys-kompetens
25. Tu-fram damminform-ationer till DC
Damminformationen är sorterad i DC
7. Hantera damminform (DC)
Åtgärd inriktgärd



Helen Alm and Johanna Larsson 2013

- Corresponding to dam safety strategic work



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