COST Action IS1304 workshop

Expert Judgement in Project and Asset Management

Practice and Challenges

Science Centre
Delft, The Netherlands
12th – 14th October 2016

Dear Participant,

We are very pleased to welcome you in Delft for our meeting “Expert Judgment in Project and Asset Management: practice and challenges”. Project and asset management are of great relevance for society and hence also for decision makers in both private and public sector. The decision making process when it comes to project and asset management has often to be performed while facing large uncertainties. Adequate measurements to formally quantify these are frequently lacking. Moreover, the decision making process is often hampered by lack of data, or data that might not be reliable and/or representative. In both cases, the option is to recourse to expert opinions as an alternative. Unfortunately, most of the times the inclusion of expert opinions in project and asset management is performed in an informal way. These may lead to inaccuracies that could result in over or underestimation of risks and costs in the management of projects and assets.

Over the past 25 years, important progress has been made in the field of Structured Expert Judgment (SEJ). SEJ is an effort to subject the process of using expert opinions for decision making to more scientific standards. Despite this progress, many challenges remain in this field, one of them being bridging the gap between practice and theory. For asset and project management this is a challenge that still needs to be tackled.

TU Delft and TNO (The Netherlands Organization for Applied Scientific Research) are happy to welcome you for this meeting. Our objective is bringing together expertise from different fields to discuss:

- the current practice for including expert opinions in project and asset management
- the state of the art techniques for structured expert judgment
- the challenges of bringing both fields closer together.

Over the three days of the workshop we will have a total of 16 talks by different colleagues around Europe and the United States. We will also have a session for Early Stage Researchers and the opportunity to meet with members from different Working Groups of our COST Action. Of course there will also be opportunity for social events in order to meet with our colleagues in a more informal setting.

We take this opportunity to thank you for your kind participation and to wish you a productive and successful meeting.

Kind regards,

Local Organising Committee

TU Delft: George Leontaris, Tina Nane, Oswaldo Morales Nápoles
TNO: Nicole van Elst, Wim Courage, Linda Abspoel, Imelda van de Voorde

Expert Judgment for Asset and Project Management Practice and Challenges

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Expert Judgment Network: Bridging the Gap Between Scientific Uncertainty and Evidence-Based Decision Making

Wednesday 12 October

Time table	Topic	Speaker
13.00 - 13.30	*Registration + Coffee*	
13.30 - 13.45	Welcome	Imelda van de Voorde & Oswaldo Morales Nápoles
13.45 - 14.30	Breaking news from Structured Expert Judgement	Roger Cooke
14.30 - 15.15	Monitoring Uncertainty in Project Completion Times: A Bayesian Network Approach	René van Dorp
15.15 - 15.45	*Coffee break*	
15.45 - 16.30	National Risk Assessment	Peter van Scheepstal & Leendert Gooijer
16.30 - 17.00	Hybrid Demand Forecasting	Naoufel Cheikhrouhou
17.00 - 17.15	Discussion / preliminary conclusions	

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Thursday 13 October

Time table	Topic	Speaker
09.00 - 09.30	Why Preference Elicitation is not Expert Judgement	Simon French
09.30 - 10.00	Defense Materiel Proces: Replacement of the Royal Netherlands Air Force F-16	Nicole van Elst
10.00 - 10.30	A Bayesian approach to improving estimate to complete	Fabrizio Ruggeri
10.30 - 11.00	*Coffee break*	
11.00 - 11.30	The accountability imperative for quantifying the uncertainty of emission forecasts	Daniel Puig
11.30 - 12.00	Uncertainty in climate predictions: how to take this into account for dike design?	Robert Vos
12.00 - 12.30	Uncertainties in lifetime and replacement cost estimates of bridges and hydraulic structures in The Netherlands	Robin Nicolai
12.30 - 13.30	*Lunch*	
13.30 - 14.00	Using cost based time series to assess the calibration levels of in-flight major projects	Jamie Walker
14.00 - 14.30	Structured expert judgment in degradation and maintenance modelling for steel bridges	Alex Kosgodagan
14.30 - 15.00	*Coffee break*	
15.00 - 16.00	Panel session: ESR - Özlem Karsu / Role of expert judgement in healthcare resource allocation and policy making - George Leontaris / Offshore Windfarms - Simona Miraglia / Integration of sustainability in risk based decision making - Mirjam Nelisse / Collision risks ships	Chair: Simon French
16.00 - 16.30	Discussion / preliminary conclusions	
17.30 - 19.15	*Guided tour and boat trip*	
19.30 - 22.00	*Dinner*	

Expert Judgment for Asset and Project Management Practice and Challenges

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Expert Judgment Network: Bridging the Gap Between Scientific Uncertainty and Evidence-Based Decision Making

Friday 14 October

Time table	Topic	Speaker
09.00 - 09.30	Using expert judgement for evaluation	Aletta Eikelboom
09.30 - 10.00	Use of paired comparison to identify hazard scenarios for assessing the resilience of critical infrastructure	Ioanna Ioannou
10.00 - 10.30	*Coffee break*	
10.30 - 11.00	Cyber Enterprise Risk	Colette Jeffery
11.00 - 11.30	Supporting replacement investment decisions in capital intensive industry	Susanna Kunttu
11.30 - 12.30	Discussion and Conclusions	
12.30 - 13.30	*Lunch*	
13.30 - 15.00	Working group sessions	
15.00 - 15.30	Reports from Working Groups and Closing	

Abstracts

Breaking news from Structured Expert Judgement
Roger M. Cooke

There are several significant developments surrounding SEJ and the COST initiative, including
- Publications of the WHO Industrial scale application of SEJ to food safety
- A Perspective in Nature Climate Change advocating SEJ for quantifying climate uncertainty
- Two upcoming publications on out-of-sample validation for SEJ
- A review article on dependence
- New applications to breastfeeding and IQ (Cooke and Colson), Insuring against Terrorism (Ismail) and Efficacy of antibiotics (Colson), and US Geological service (Aspinall).

This talk will briefly review these developments, focussing on out-of-sample validation.

Monitoring Uncertainty in Project Completion Times: A Bayesian Network Approach
J. René van Dorp
Department of Engineering Management and Systems Engineering, The George Washington University, 800 22nd Street NW, Suite 2800, Washington, DC 20052, USA

Recent advances in the Program Evaluation and Review Technique (PERT) have addressed a lack of statistical dependence modeling among activity duration uncertainties. However, their applications are hampered by two aspects: (1) the coherent monitoring of remaining project uncertainty as a project progresses by taking advantage of the degree of statistical dependence relies on complex computationally intensive procedures and (2) the specification of the degree of statistical dependence suffers from a curse of dimensionality in an application domain which already burdens experts with the estimation of activity most likely, lower and upper bound estimates. In this paper, we construct a continuous Bayesian Network (BN) model addressing both aspects by taking advantage of the BN inference procedure in the software AgenaRisk®. Specifically, the BN described defines a multivariate joint distribution between activity durations by incorporating only two additional dependence parameters to specify a degree of statistical dependence among the activities. Under certain dependence parameter settings, this BN model reduces to a multivariate joint distribution of statistically independent activities with the same marginal uncertainty description as the PERT method of Malcolm et. al (1959). To further facilitate application, an expert judgment elicitation procedure is developed to specify the two BN's dependence parameters via the elicitation of a sparse conditional median matrix of activity durations along a project network's paths. An illustrative example using a case study demonstrates the potential increased pace of learning about remaining project schedule uncertainty under a mild degree of statistical dependence by taking advantage of the Bayesian paradigm.
Keywords – Project Schedule Risk, Bayesian Networks, Statistical Dependence, Uncertainty Modeling, Risk Analysis.

National Risk Assessment
Peter van Scheepstal & Leendert Gooijer

In support of the inter-departmental National Safety and Security Strategy, a National Risk Assessment (known by the initials NRA) is carried out once a year. The exercise involves exploring a number of safety and security themes by analysing various scenarios in the context of a standard reference framework. The approach is referred to as the NRA method. The findings are intended to provide policy makers with insight into the relative likelihood and impact of the various scenarios. Such insight is important for specifying capability implications, formulating policy, and defining priorities, with the aim of preparing the Netherlands as well as possible for various types of disaster and threat.

Why Preference Elicitation is not Expert Judgement
Simon French, University of Warwick

Most theories of decision, particularly the subjective expected utility model of Bayesian decision theory, separate the decision maker's uncertainties from her preferences. These are then modelled separately and before being combined to offer an indication to the decision maker of how to balance these factors in ranking the various options. Decision theories are essentially individualistic. Inconsistencies and impossibilities abound when one tries to develop similar theories for groups and societies. But this does not mean that individualistic decision theories cannot support group or societal decision making, only that they need be applied and interpreted with some sophistication. One issue is that the uncertainties that are modelled in decision analyses for groups and societies are generally expected to provide a *rational* synthesis of the advice offered by experts; whereas the group or societal preferences are expected to be built according *democratic* principles. Sadly, rationality and democracy are sometimes poor bedfellows and this means that the processes and procedures for eliciting expert judgements of uncertainties need to differ from those for eliciting preferences.

Defense Materiel Proces: Replacement of the Royal Netherlands Air Force F-16
Nicole van Elst

The F-16's of the Royal Netherlands Air Force are rapidly becoming obsolete, both technically and operationally. As a result, the Defense Materiel Organization (DMO) of the Netherlands' Ministry of Defense (MOD) formulated a requirement to replace the F-16 with a new manned multirole combat aircraft. A project organization, the F-16 Replacement Project Office was created to manage the replacement process. The evaluation of candidates (1999-2001), supported by TNO (which was characterized as "unbiased, transparent & traceable" by a parliamentary committee), lead to the selection of the Joint Strike Fighter (JSF) as the "best candidate for the best price". As a result, the Netherlands Government in 2002 decided to participate in the System Design and Demonstration (SDD) phase of the newly called F-35 Joint Strike Fighter. With parliamentary approval, the Ministry of Defense entered the so-called acquisition-preparation phase for the F-35 which was formulated to be a *de facto* choice for the F-35. Since 2002 the DMO Project Office, supported by TNO, focuses on three main activities: the acquisition of the new aircraft, the protection of Dutch interests in the development of the F-35 and the transition towards the new organization operating the new aircraft.

In 2008 the Netherlands Government decided to participate in the Operational Test & Evaluation (OT&E) of the F-35 taking place in the United States, a necessary step towards an Initial Operational

Capability, by signing a Memorandum Of Understanding with the US Government in which The Netherlands committed to purchasing two test aircraft to be integrated in a test pool (the first of these aircraft rolled out of the factory this year). However, the same year (2008), one of the coalition partners required a re-evaluation of potential candidate aircraft on three main aspects: Quality, Cost and Timeline/Delivery. This re-evaluation was once again carried out by TNO and NLR. Amongst the methods used were Multi Criteria Analysis combined with operational mission analysis and availability analysis, as well as Life Cycle Cost analysis. One of TNO's main challenges in this re-evaluation (from a decision support point of view) was to design an unbiased, transparent and traceable decision process given the fact that both the available information and the development stage differed for the candidates. The inclusion of uncertainty and sensitivity analysis to determine the robustness of the results was an important aspect. The process was monitored and favorably reported on by RAND Europe and the Audit Services of the Ministry of Defense and of Economic Affairs. The results were presented to parliament in December 2008 by the Undersecretary of Defense. The re-evaluation of candidates and the role of expert judgement is the subject of this presentation".

A Bayesian approach to improving estimate to complete
Fabrizio Ruggeri

The capability to develop a reliable 'Estimate at Completion' from the earliest stage of project execution is essential in order to develop a proactive project management. This paper provides a methodology to support the development of the Estimate at Completion in large engineering projects. In order to accomplish this aim, a model to formulate estimates at completion is presented which integrates through a Bayesian approach three knowledge sources: experts' opinions, data from past projects and the current performance of the ongoing project. The model has been applied to three Oil and Gas projects in order to forecast their final duration and cost.

The accountability imperative for quantifying the uncertainty of emission forecasts
Daniel Puig

Governmental climate change mitigation targets are typically developed with the aid of forecasts of greenhouse-gas emissions. The robustness and credibility of such forecasts depends on the extent to which forecasting approaches stand scientific scrutiny. We apply a transparent and replicable method to quantify the uncertainty associated with projections of gross domestic product growth rates for Mexico, a key driver of greenhouse-gas emissions. We use those projections to produce probabilistic forecasts of greenhouse-gas emissions for the country. We contrast our probabilistic forecasts with Mexico's governmental deterministic forecasts. We show that, because they fail to reflect uncertainty, deterministic forecasts are ill-suited for use in target-setting processes. We argue that governments should be held accountable for the appropriateness of the forecasting approach applied to prepare governmental forecasts, especially when those forecasts are used to derive climate change mitigation targets. We contend that this largely under-researched issue is central to current international climate change negotiations.

Uncertainty in climate predictions: how to take this into account for dike design?

Robert Vos, Rijkswaterstaat WVL

In the Netherlands dikes are usually designed for life spans of 50 years and constructions for 100 years. Climate predictions for sea level rise and increase of river discharges are taken into account while any cimate change in the windfield is neglected. At present, the climate predictions are still based on the KNMI'06 scenario's. River discharge of Rhine and Meuse is modelled with the GRADE modelling approach which takes into account climate change in precipitation and temperature in the whole river region (Hegnauer, 2015).

Within such an approach any uncertainty of the climate predictions is neglected and optimization of the life span is not possible. It is generally felt that this leads to overestimation of the required dike height in the future. Therefore, Rijkswaterstaat and DGRW have commissioned KNMI to make predictions of climate uncertainty as well using so-called probability density functions. First results for sea level rise have recently been obtained by Le Bar et al. (2016). These will be used in a next step by Deltares (Smale, 2016) in order to determine the optimal life span and an optimal dike height supplement.

Climate uncertainty has 3 main components: 1) Natural Variability, 2) Modelling uncertainty and 3) uncertainty in anthropogenic effects. The latter is mainly due to emissions of CO2 and aerosols. At present Rijkswaterstaat and DGRW focus only on the uncertainty of the first two sources since uncertainties in CO2 emissions are difficult to assess and also require political choices. In our analysis, at present, a choice is circumvented by performing the uncertainty analysis for various RCP scenarios (Le Bar, 2016), or for various KNMI'06 scenario's (Rijnen, 2016).

Recently, first results using a simple cost-benefit analysis for sea level rise (based on the KNMI'06 scenario's) were obtained by Rijnen from TU Delft (2016) and they confirm that the present approach for dike height design in coastal areas leads to an overestimation of the required dike height supplement and optimal life span.

The method is not yet applicable for rivers since this will be a very costly modelling step using GRADE. Short cuts in saving computer time have recently been suggested by KNMI (Beersma, 2016). Moreover, for rivers it is felt that other arguments in choosing the optimal life span (like social impact) might have a large impact as well.

References

- M. Hegnauer. Afvoerstatistiek Ontwerp Instrumentarium (OI) 2014. Deltares memo 1220042-004-ZWS-0001. 27 Juli 2015.
- D. Le Bar, H. de Vries, S Drijfhout and B. van der Hurk. Probabilistic approach of sea level along the Dutch Coast. KNMI report 15/9/2016, KNMI, de Bilt.
- A. Smale. Plan van Aanpak rekenen met klimaatonzekerheden. Deltares memo 1221208-000-HYE-0006. 13 april 2016.
- K.M.F. Rijnen. The implications of Sea Level Rise Uncertainties for Dike Design Decisions. Master Thesis a TU Delft. In preparation (publication October 2016).
- J. Beersma, How to obtain probabilistic discharge scenario's for the Meuse and the Rhine rivers? KNMI paper 14/9/2016, KNMI, de Bilt.

Uncertainties in lifetime and replacement cost estimates of bridges and hydraulic structures in The Netherlands
Robin Nicolai

Rijkswaterstaat (RWS), the executive agency of the Ministry of Infrastructure and the Environment in the Netherlands, maintains three networks in the country: the main highways, the main waterways, and the main bodies of water such as the large rivers and the coastal area of the North sea. The former network includes about 3500 bridges and overpasses. The latter two networks include about 650 hydraulic structures such as sluices, ship locks, bridges over rivers, etc.
The average age of the structures in these networks increases. Many hydraulic structures date from just before or after the second World War. Furthermore, the use of the network increases. In order to make adequate maintenance decisions it is required to collect information on the time and cost of maintenance. As a first step the age distribution of the structures is reviewed and the remaining lifetimes are estimated. These estimates are then used to calculate the life-cycle cost and the budget requirements for the replacement of structures.

Using cost based time series to assess the calibration levels of in-flight major projects
Jamie Walker

Research has shown that most projects that have a total budget in excess of around $100m tend to run late and overspend, and that this has been a long-term trend that shows little sign of abating. It is common to collect data on completed projects and compare their final durations and costs with their initial contractual targets, and this data is somewhat useful from a 'post-mortem' perspective in that it could be used to help new projects to improve their subsequent performance levels. An alternative to this approach would be to produce a set of probabilistically defined time-series from a costed schedule model that has been collectively created by multiple experts and analysts, and then compare these time-series to the related project's in-flight accounting data. A similar approach is commonly used under the heading of 'Earned Value' where a project's monthly spends are compared to the level of progress it was scheduled to make at that point and the current level of completion of its workscope, but it is rare for such comparisions to be made between such sets of data and a probabilistically defined time-series from a model. For this reason comparison data for several major projects from an industrial setting will be presented and discussed with regard to their apparent levels of calibration, the technical and behavioural reasons why some models might be better calibrated than others, and possible improvements that could be made in the elicitation or model-building processes that might result in better calibration levels.

Structured expert Judgment in degradation and maintenance modelling for steel bridges
Alex Kosgodagan, University of Nantes

Markov-based models for predicting deterioration for civil infrastructures are widely recognized as suitable tools addressing this mechanism. The objective of this paper is to provide insights regarding a network of orthotropic steel bridges in terms of degradation. Consequently, a model combining a dynamic Bayesian network and a Markov chain is first introduced that builds up the network in a concise way. In an attempt to represent a network composed of two general classes of orthotropic steel bridges, the classical method of structured expert judgment is carried out as a quantification procedure. The first objective is to elicit indirectly transition probabilities for a Markov chain that describes how each bridge type deteriorates in time. Second, experts are asked to provide estimates on required conditional probabilities related to the Bayesian network. An in-depth analysis of the

results is presented so that remarks and observations are subsequently pointed out and, finally conclusions are drawn.

Use of paired comparison to identify hazard scenarios for assessing the resilience of critical infrastructure
Ioanna Ioannou

Critical infrastructure is exposed to a wide range of hazards which can affect their functions, integrity and have local, national or international consequences. Given the limited time and often resources, how can we select a natural or operational hazard scenario which can be used to assess the resilience of this infrastructure to disasters or emergencies? We use the paired comparison elicitation procedure in order to engage with the stakeholders and operators of a critical infrastructure and select a hazard event with which the stakeholders broadly agree with. This scenario can then be used for assessing the resilience of the examined infrastructure. This study is part of IMPROVER, a HORIZON2020 project aiming to develop a methodology to assess the resilience of critical infrastructure. The presentation will outline the methodology and bound to security classification issues, some results from the application to four living labs (i.e., 1. The port of Oslo, 2. The water network in Barreiro, 3. The A31 highway and 4. The Oresund crossing) may be included.

Developing an integrated approach to the analysis of MOD cyber-related risks
Colette Jeffery

In recent years 'cyber' has emerged as a core defence capability due to increased awareness of its pivotal role as an enabler - and disabler - for both corporate functions and military operations. As a result of the growing integration of cyber with existing capabilities, the UK MOD requires an evidence-based approach for risk management of cyber-related risks to the MOD enterprise. The Defence Science and Technology Laboratory (DSTL) developed a process to support the assessment, visualisation and documentation of cyber risks for MOD. This presentation discusses the key findings from research conducted into the risk assessment process. In particular, findings relevant to expert judgement, which is used to both assess the risks and the confidence that a decision maker should place in risk scores, are detailed.

Supporting replacement investment decisions in capital intensive industry
Susanna Kunttu

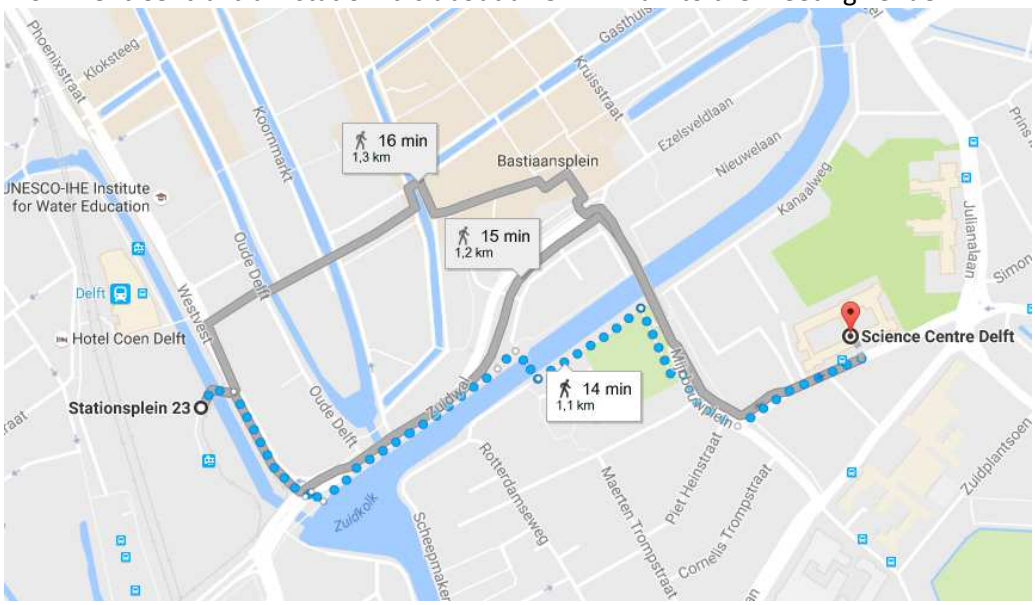
In the presentation I will demonstrate a practical method by which an investment portfolio can be selected from a long list of investment proposals. The method integrates economic evaluation and risk analysis of investments which both utilise expert judgements as the main data source.

Logistical information

Directions from Schiphol to Delft

From Schiphol a direct train leaves every half hour (x.16 and x.46, towards Vlissingen) from platform 5 or 6 (which are adjacent). The trip will take about 40 mins in total.

From Delft Central train station it is about a 15 min walk to the meeting venue:



Directions from Delft to Schiphol

From Delft central station, a direct train leaves every half hour from platform 1 (x.04 and x.34, towards Lelystad Centrum). The trip will take about 40 mins in total.

Tickets for the train

Single tickets are sold at the yellow/blue ticket machines (with the logo in BLUE on top) in the train station. A trip from Schiphol to Delft will cost € 9,80.

Meeting Venue
Address: Science Centre Delft , Mijnbouwstraat 120, 2628 RX Delft, Netherlands.
The workshop will be held in room Mekelzaal of the Science Centre, signs will show the direction to the registration desk and meeting room.

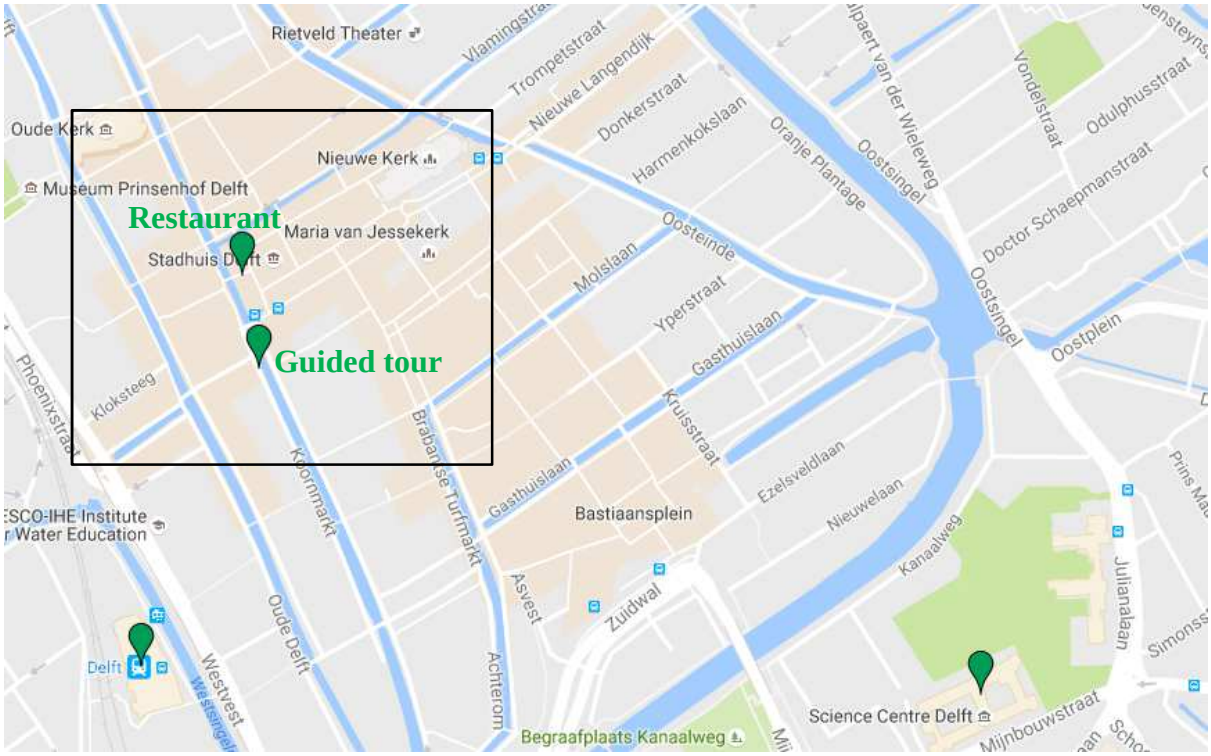
Map
An interactive map showing the meeting venue, some hotels, the locations of the social event and other important places:
https://www.google.com/maps/d/u/0/edit?hl=en&authuser=0&mid=1uXq5IuUKI7GAd6nUgrlb77yblyY

Social event
On Thursday 13 October, after the workshop, a social event is planned. The guided walking tour and boat trip will start at 17:30 from

Rederij Brands / Rondvaart Delft Koornmarkt 113 2611 ED Delft

After the tour, dinner reservations have been made at 19:30 in

Restaurant de Waag Markt 11 2611 GP Delft


Rietveld Theater
Oude Kerk
Nieuwe Kerk
Museum Prinsenhof Delft
Restaurant
Maria van Jessekerk
Stadhuis Delft
Guided tour
Trompetstraat
Nieuwe Langendijk
Donkerstraat
Harmenkokslaan
Oranje Plantage
Oostsingel
Vondelstraat
Odulphusstraat
Doctor Schaepmanstraat
Oostplein
Oostelinde
Molslaan
Yperstraat
Gasthuislaan
Kruisstraat
Ezelsveldlaan
Nieuwelaan
Kanaalweg
Julianalaan
Phoenixstraat
Klooksteeg
Koormarkt
Brabantse Turfmarkt
Gasthuislaan
Bastiaansplein
Asvest
Zuidwal
Achterom
Oude Delft
Delft
Westvest
Science Centre Delft
Mijnbouwstraat
Begraafplaats Kanaalweg


Oude Kerk
HH Geestkerkhof
't Postkantoor
Hippolytusbuurt
Papenstraat
De Vlouw
Kek - De koffiebar van Delft
Vrouwenregt
Kerkstraat
Nieuwe Kerk
Voldersgracht
Halsteeg
Markt
Oude Langendijk
Café de Wijnhaven B.V.
Restaurant
Stadhuis Delft
Maria van Jessekerk
Nieuwstraat
Burgwal
Jacob Geritstraat
Erfgoedhuis Zuid-Holland
Boterbrug
Wijnhaven
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Stadsherberg de N
Stads-Koffyhuis
Guided tour
Oude Delft
Peperstraat
Brabantse Turfmarkt
Molslaan
Klooksteeg
Binnenwatersloot
Molstraat
Pieterstraat