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Irish Rail

Asset Management of the Railway Slope Network and the Relevance to Irish Roads

TII National Roads Conference, Mullingar

Paul Doherty and Catherine Joyce, 28th September 2016

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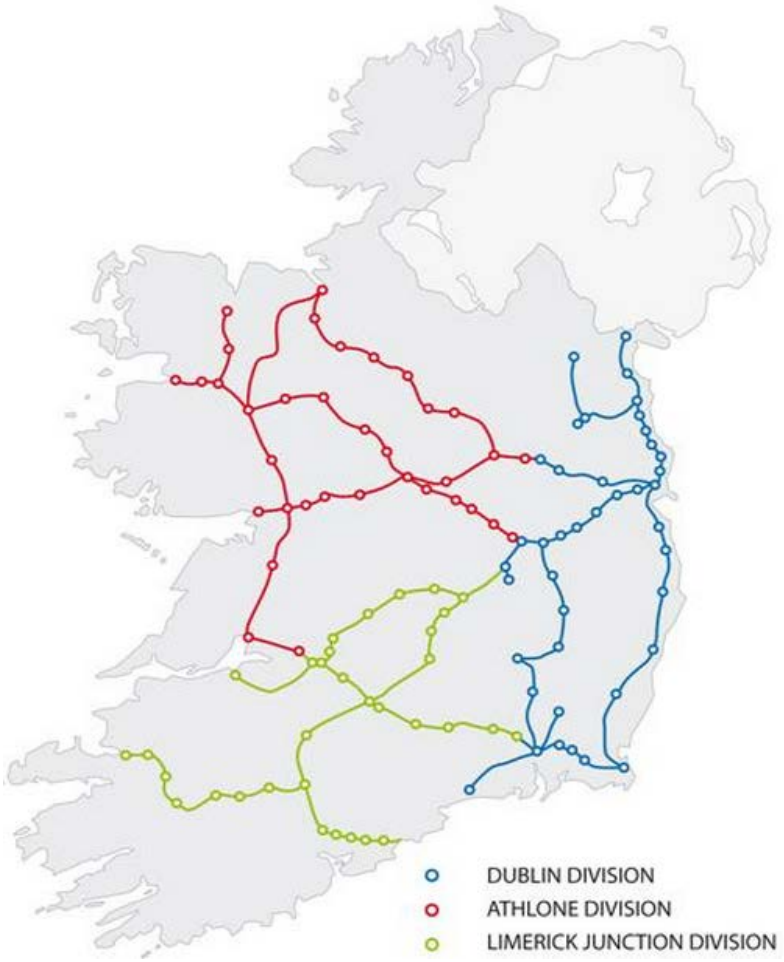
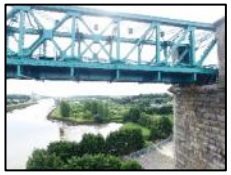


2,800 km Track


3,700 Cuttings & Embankments (1,300 km)



3,700 Bridges

995 Level Crossings



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Infrastructure Asset Management System (IAMS)

Iarnród Éireann Infrastructure
IAMS
Infrastructure Asset Management System

SAP PM

GIS Viewer

Asset Register

Work Bank

Other SAP Modules

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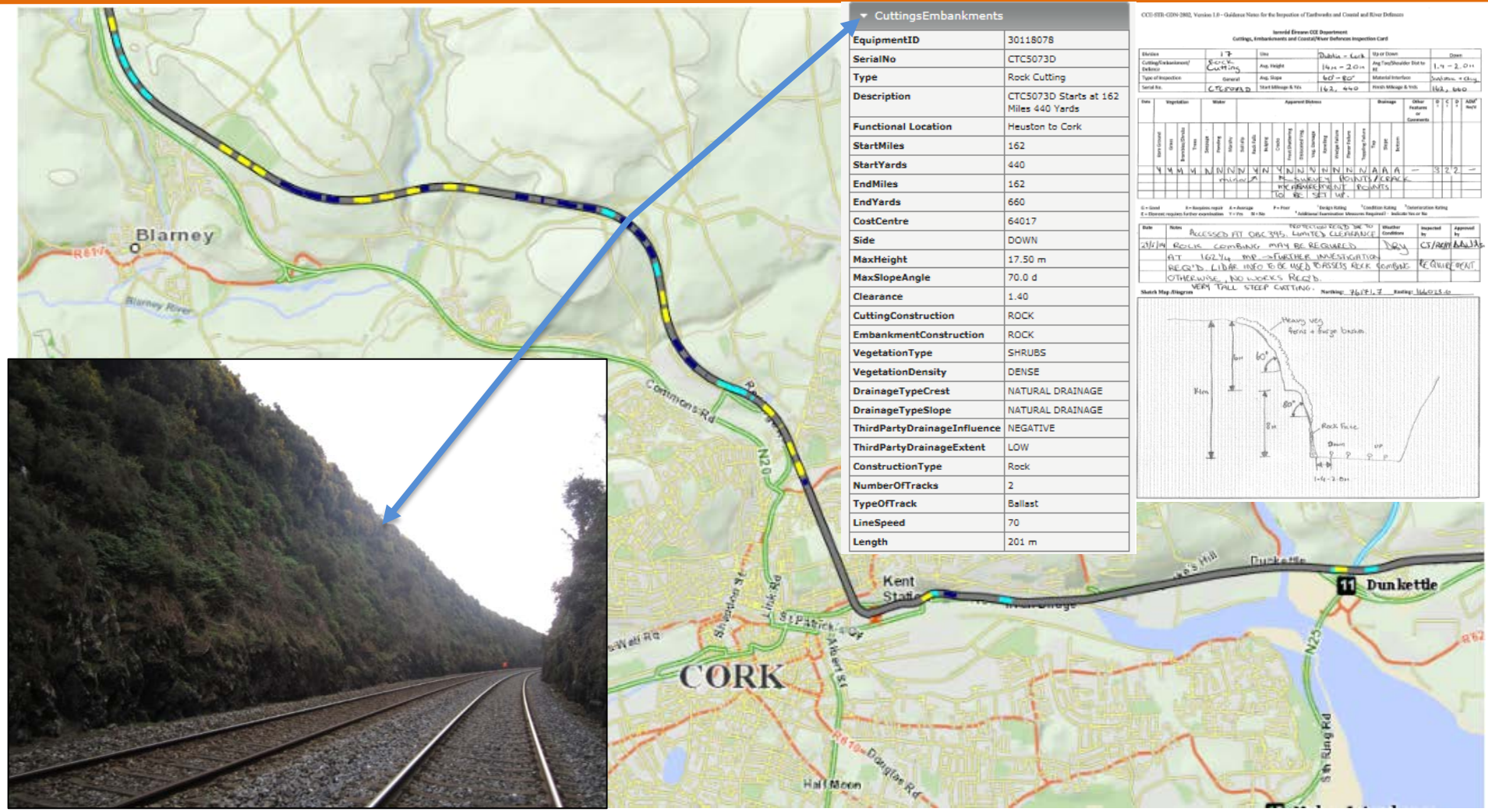
Representation of Asset on IAMS



CuttingsEmbankments	
EquipmentID	30118078
SerialNo	CTC5073D
Type	Rock Cutting
Description	CTC5073D Starts at 162 Miles 440 Yards
Functional Location	Heuston to Cork
StartMiles	162
StartYards	440
EndMiles	162
EndYards	660
CostCentre	64017
Side	DOWN
MaxHeight	17.50 m
MaxSlopeAngle	70.0 d
Clearance	1.40
CuttingConstruction	ROCK
EmbankmentConstruction	ROCK
VegetationType	SHRUBS
VegetationDensity	DENSE
DrainageTypeCrest	NATURAL DRAINAGE
DrainageTypeSlope	NATURAL DRAINAGE
ThirdPartyDrainageInfluence	NEGATIVE
ThirdPartyDrainageExtent	LOW
ConstructionType	Rock
NumberOfTracks	2
TypeOfTrack	Ballast
LineSpeed	70
Length	201 m

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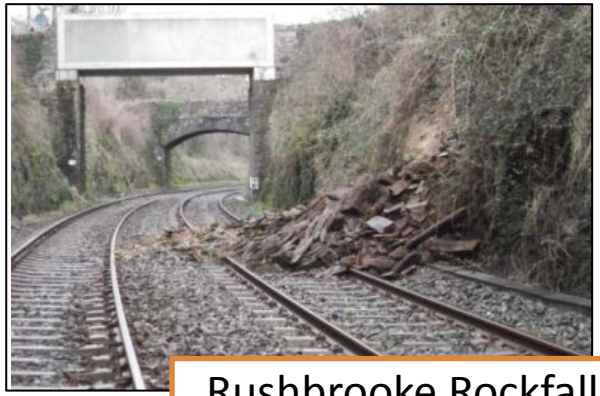
Case Studies - Recent Failures

Wicklow Derailment 2009

Cabra Slope Failures 2012

Waterford Station Rockfall Dec 2013



Rushbrooke Rockfall March 2014

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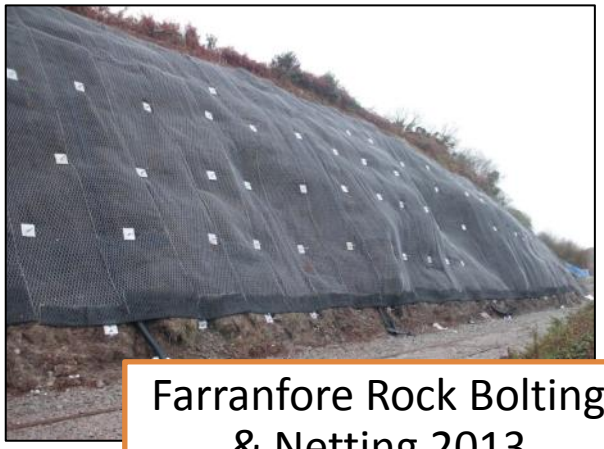
Case Studies - Recent Remediation



Farranfore Rock Bolting & Netting 2013

Rushbrooke Rock Nailing & Shotcreting 2014

Mallow-Tralee Combing & Rock Removal 2015

Bray Head Rock Nailing & Netting 2015

IÉ Need for a Decision Support Tool

- Difficult to predict failures
- Subjective assessment of assets
- Network-wide review of assets required
- Robust procedures for safe management of assets
- Decision support tool for maintenance & renewals budgets
- Life-cycle management of assets

Introduction

- Gavin & Doherty Geosolutions (GDG) is a specialist geotechnical engineering consultancy
- Offices in London, Edinburgh, Dublin and Belfast.
- GDG was formed in 2011 in a challenging market
- Grown throughout the last five years
- Team of 25+ highly qualified engineers
- Majority of our staff are PhD qualified
- We provide innovative geotechnical solutions across a broad range of engineering problems

Risk Model Development

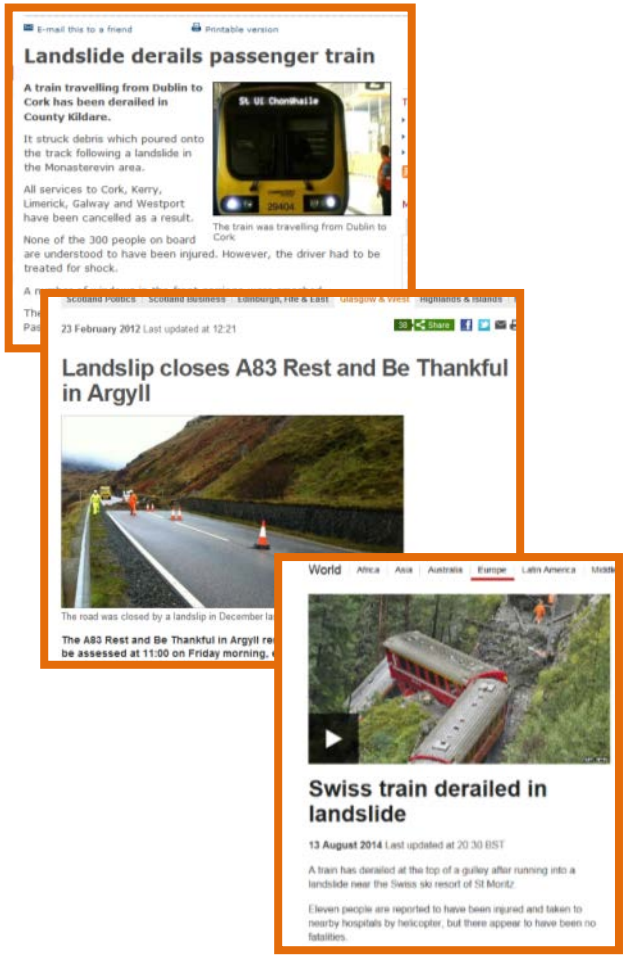
- **DRIVERS**:

- Heavy reliance on visual assessments (walk-over surveys, internal reports)

- Subjective consideration of past failures, with no direct analysis of failure modes (e.g. Planar/ translation, etc.)

- Move from reactive to predictive analysis of the network risk

- Ensure that slope risk can be analysed in a live process to consider variables such as rainfall



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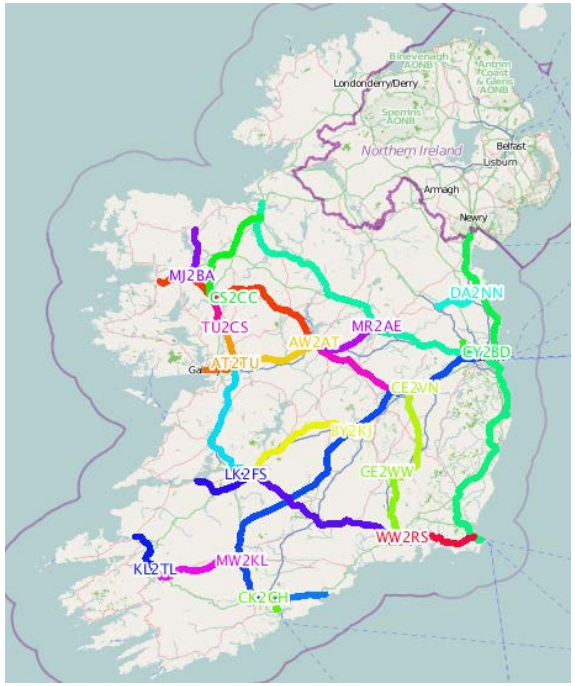
Risk Model Development

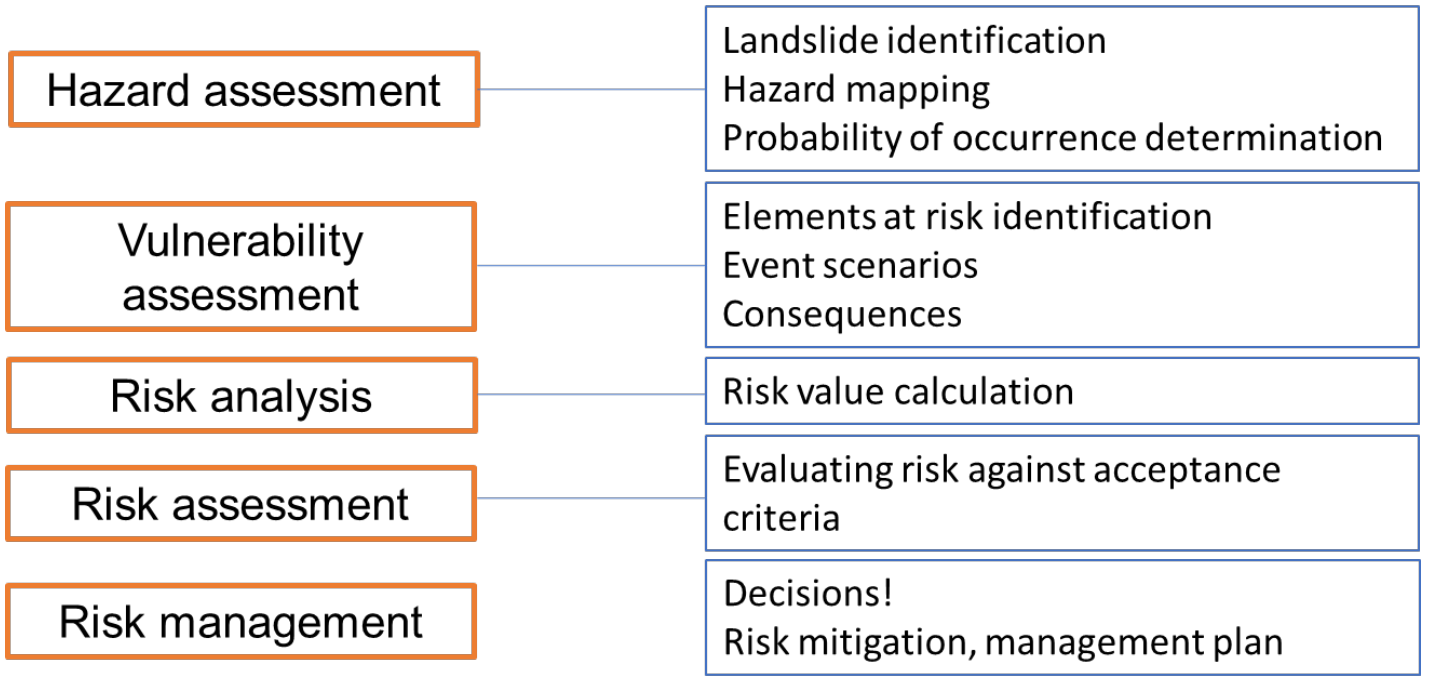
Solution



- Risk management model
- Risk assessment for each geotechnical asset on the network
- Based on already existing data and advanced geotechnical analyses for slope stability
- Decision Support Tool with in-built cost-benefit analysis for risk management strategies
- The tool is easily updated by final user

Risk Model Development

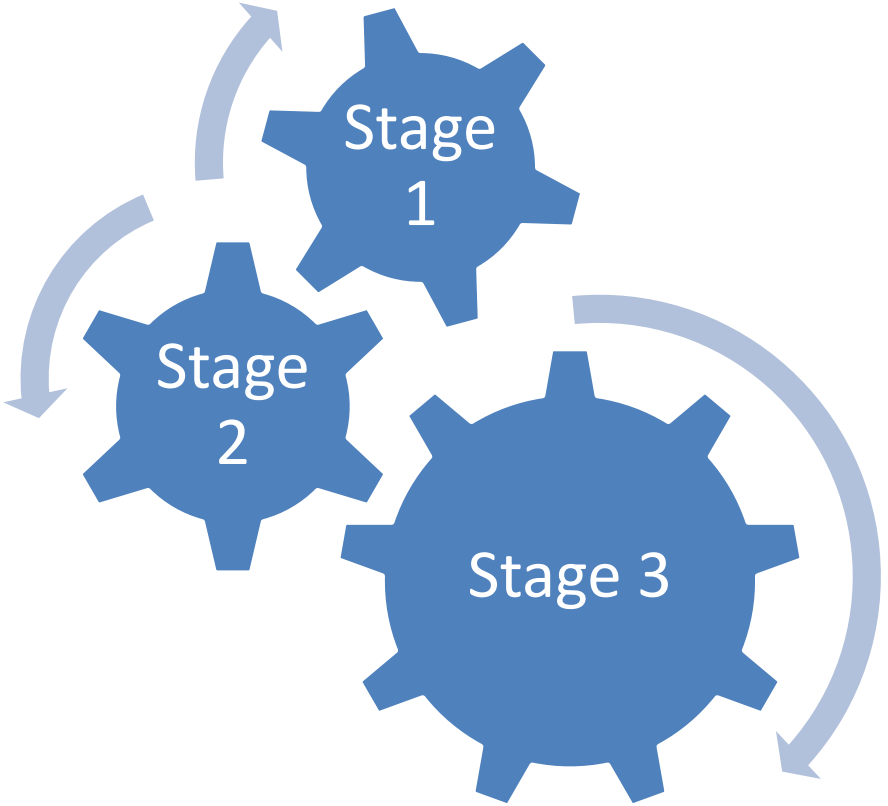
- Risk values – product of hazard and vulnerability assessments of elements at risk
- R = f [H, V, E]



Risk Model Development

3 STAGE PROCESS

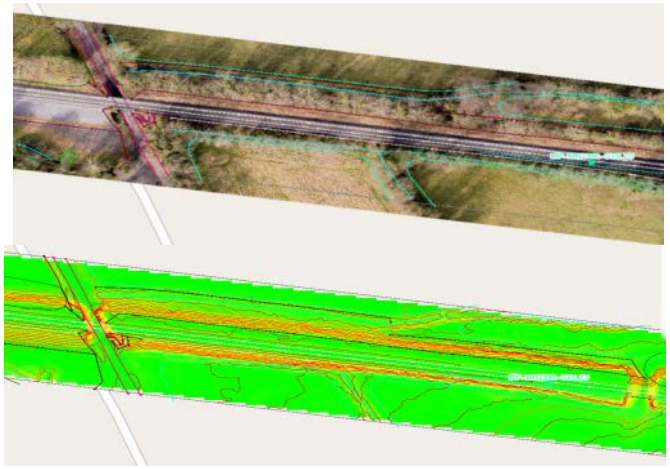
- Stage 1: Data requirements and initial hazard model
- Stage 2: Model refinement and Vulnerability assessment
- Stage 3: Risk Model and Decision Support Tool

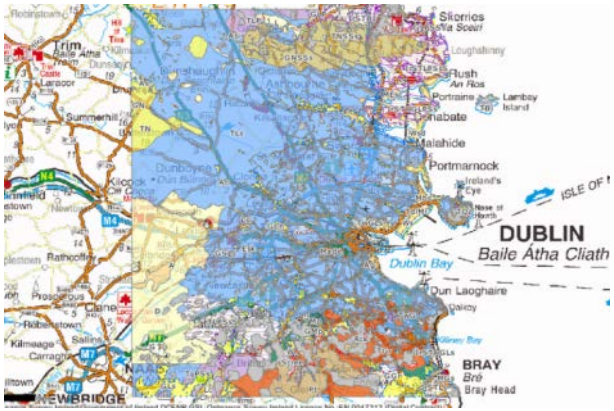


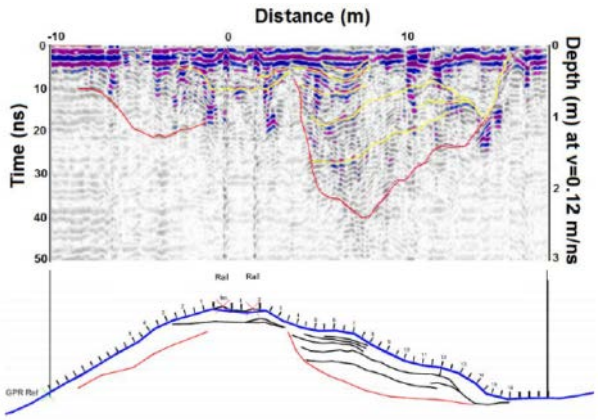
Risk Model Development

STAGE 1

- Data Sources
- Asset Inventory restructured
- Influencing parameters defined and quantified
- Database populated
- Probabilistic failure model developed

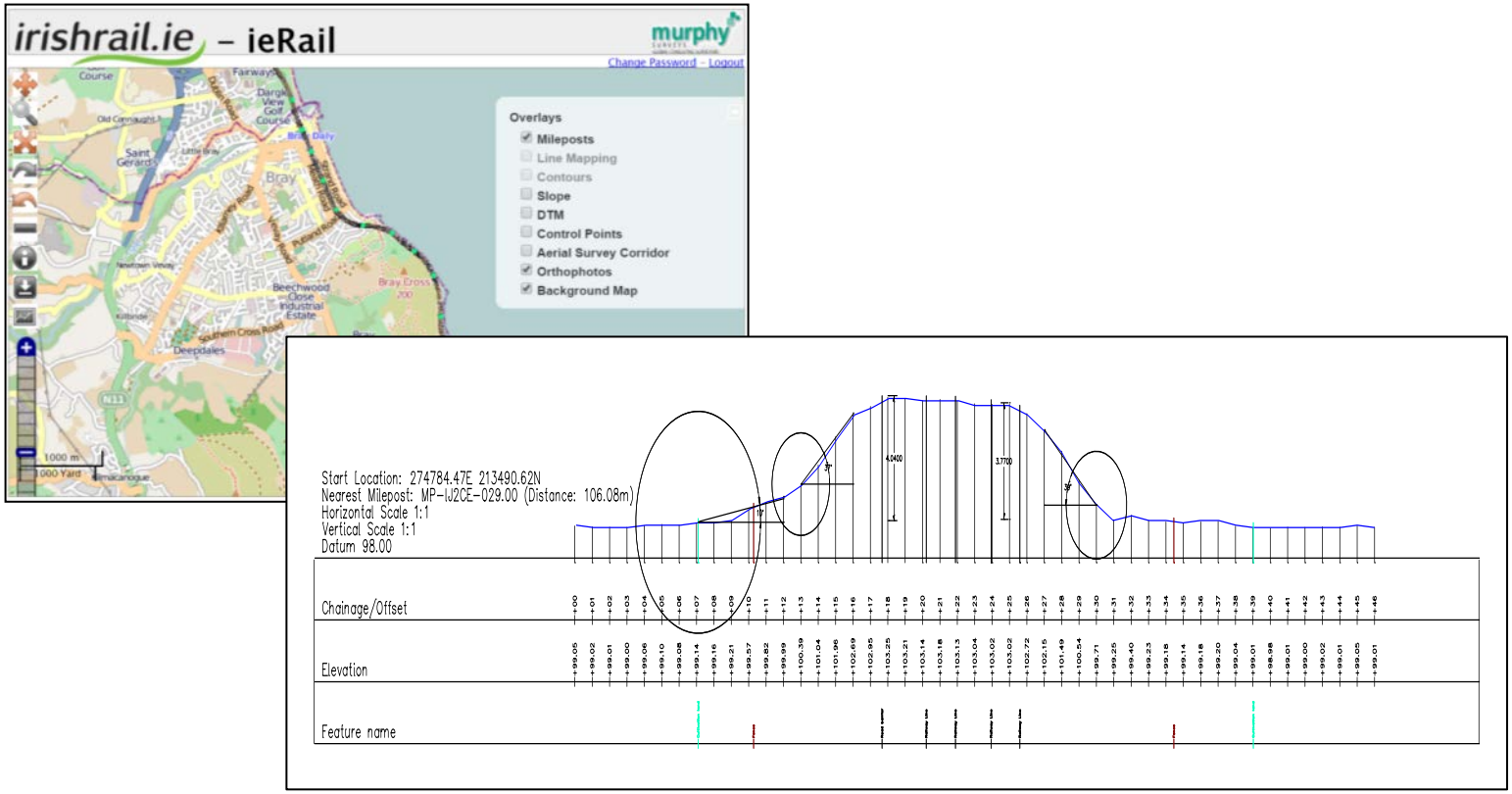






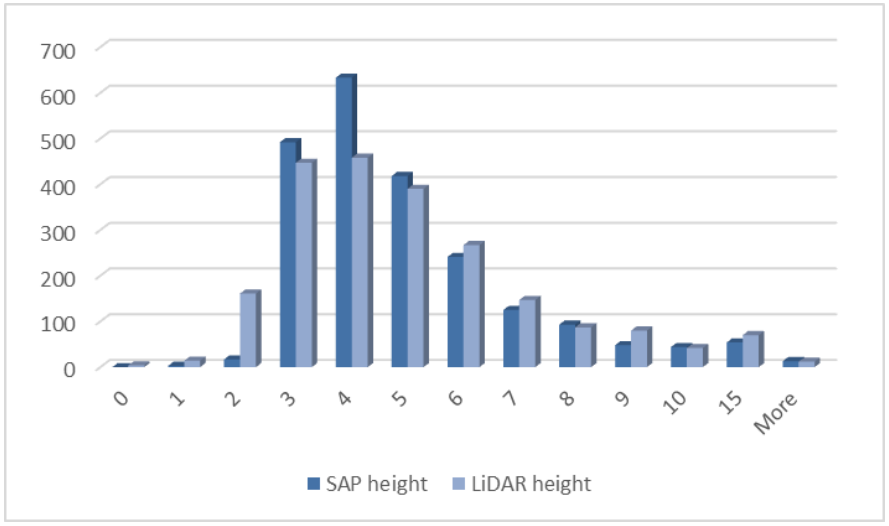
LiDAR Processing

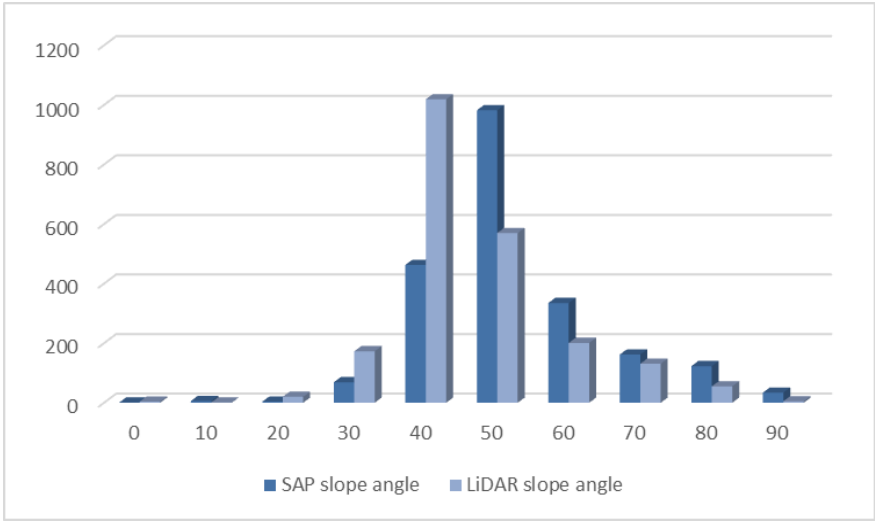
- LIDAR Data: Critical Cross Sections Identified for Every Asset



LiDAR Processing

- Slope Characteristics: Comparison of Old versus New Data for Network





Risk Model Development

STAGE 1 : FAILURE MODES CONSIDERED

- TRANSLATIONAL
- ROTATIONAL
- WEDGE

Extreme Rainfall Return Periods

Location: Gorey, Co. Wexford
Average Annual Rainfall: 982

Maximum rainfall (mm) of indicated duration expected in the indicated return period.

	Return Period (years)								
Duration	1/2	1	2	5	10	20	30	50	100
1 min				1.8	2.1	2.4	2.7	3.0	3.4
2 min				3.1	3.5	4.2	4.6	5.2	5.9
5 min				5.5	6.4	7.6	8.3	9.4	10.8
10 min				7.8	9.2	11.0	12.2	13.9	16.0
15 min	4.9	6.2	6.9	9.5	11.6	14.0	15.6	17.8	21
30 min	6.7	8.3	9.3	12.6	15.4	18.5	20.5	23	27
60 min	8.8	11.0	12.3	16.4	19.7	24	26	30	34
2 hour	11.8	14.3	16.0	21.1	25	30	33	37	43
4 hour	16.2	19.6	21.5	28	32	37	41	45	52
6 hour	19.7	23.6	26	33	38	44	48	53	61
12 hour	25.4	30	33	42	49	55	60	66	75
24 hour	32	38	41	51	59	67	73	80	90
48 hour	39	46	51	63	71	81	87	95	107
96 hour									

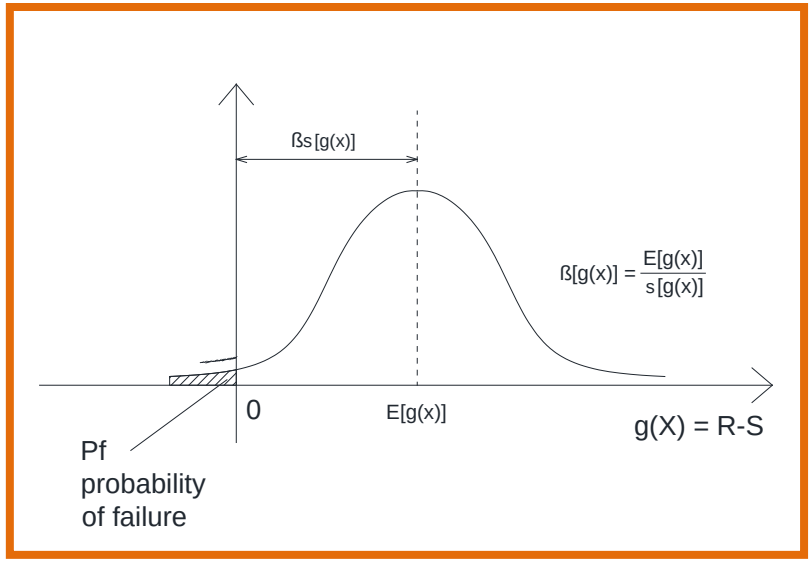
Notes: Larger margins of error for 1, 2, 5 and 10 minute values and for 100 year return periods

M50/M52d: 0.28

Risk Model Development

STAGE 1 : PROBABILISTIC MODELLING

- High Level of Uncertainty Across the Asset Characteristics
- Consider COV of input parameters depending on data source
- Develop quantifiable risk profiles
- Hasofer Lind method used to calculate the probability of failure associated with each asset and its coupled limit state
- Outputs: reliability index (β), probability of failure



Outputs: reliability index (β), probability of failure

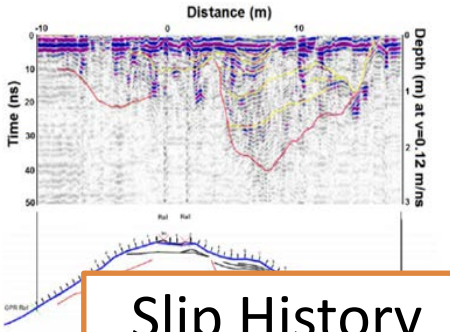
Risk Model Development

STAGE 2: MODEL REFINEMENT (HAZARD ANALYSIS)

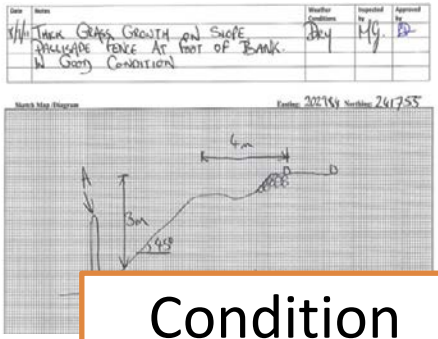
- Consider qualitative variables within a Degradation Factor

Drainage

Vegetation



Slip History

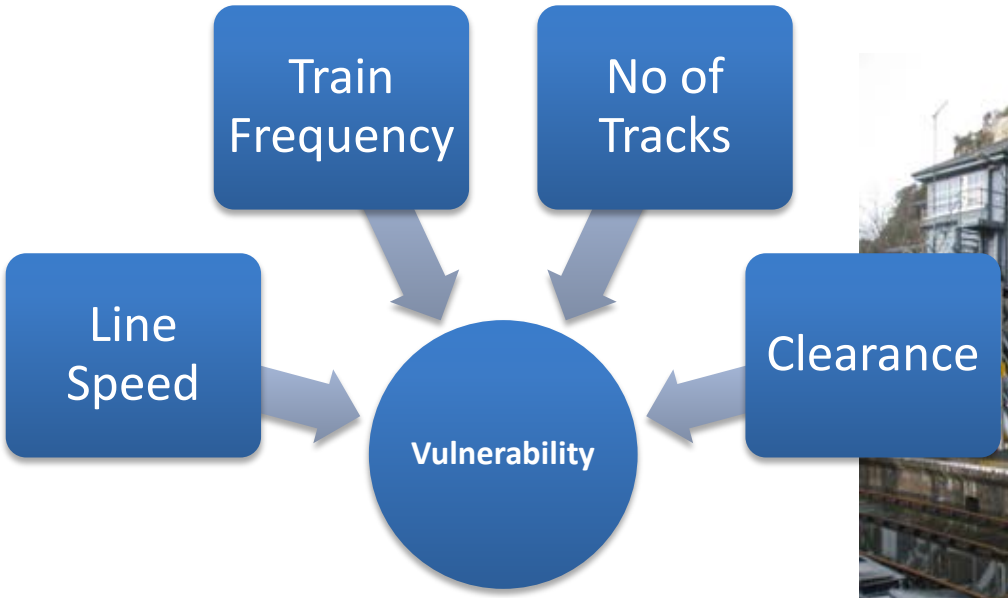


Condition

Risk Model Development

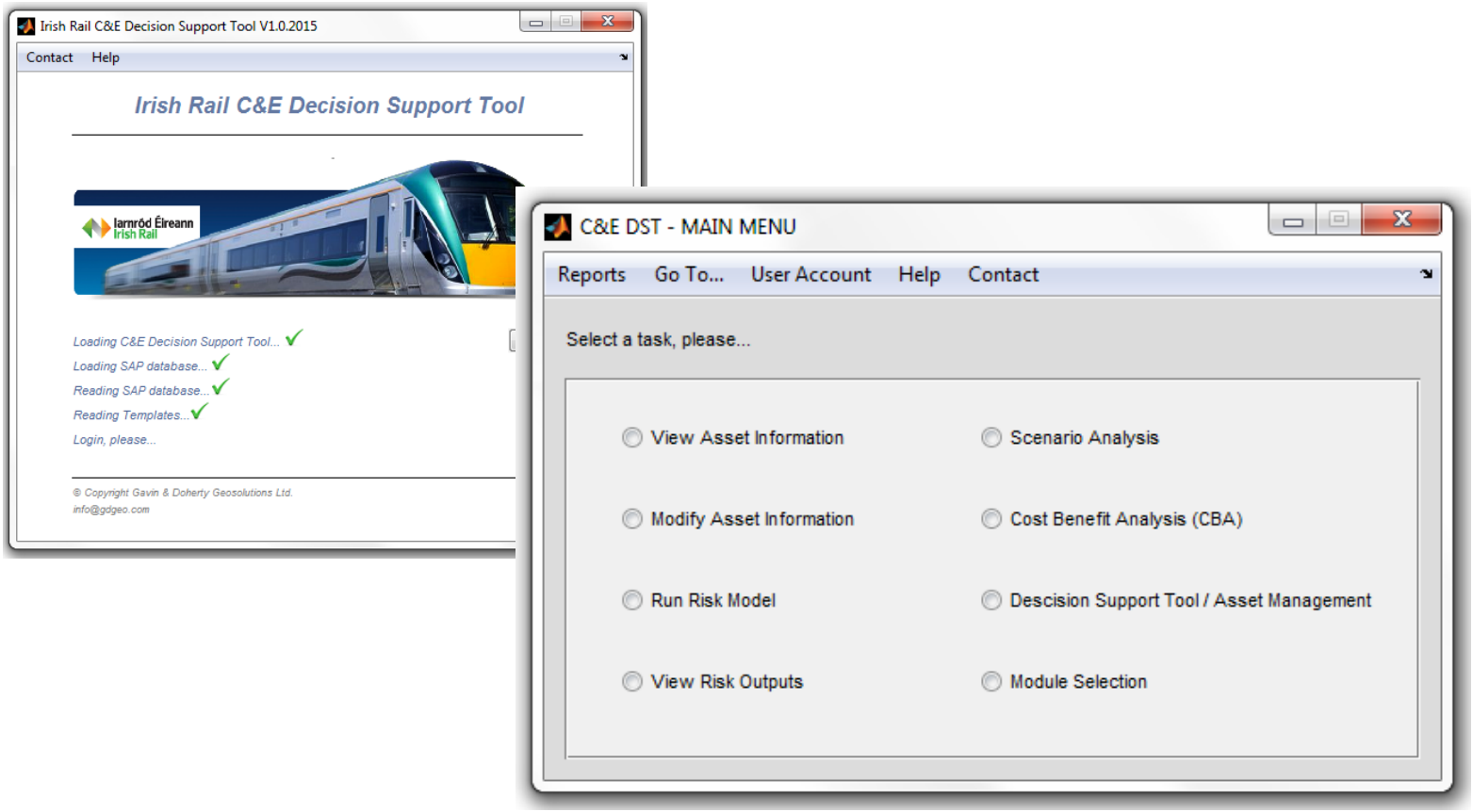
STAGE 2: VULNERABILITY ASSESSMENT & CONSEQUENCE ANALYSIS

- If slope fails – what happens next?



Risk Model Development

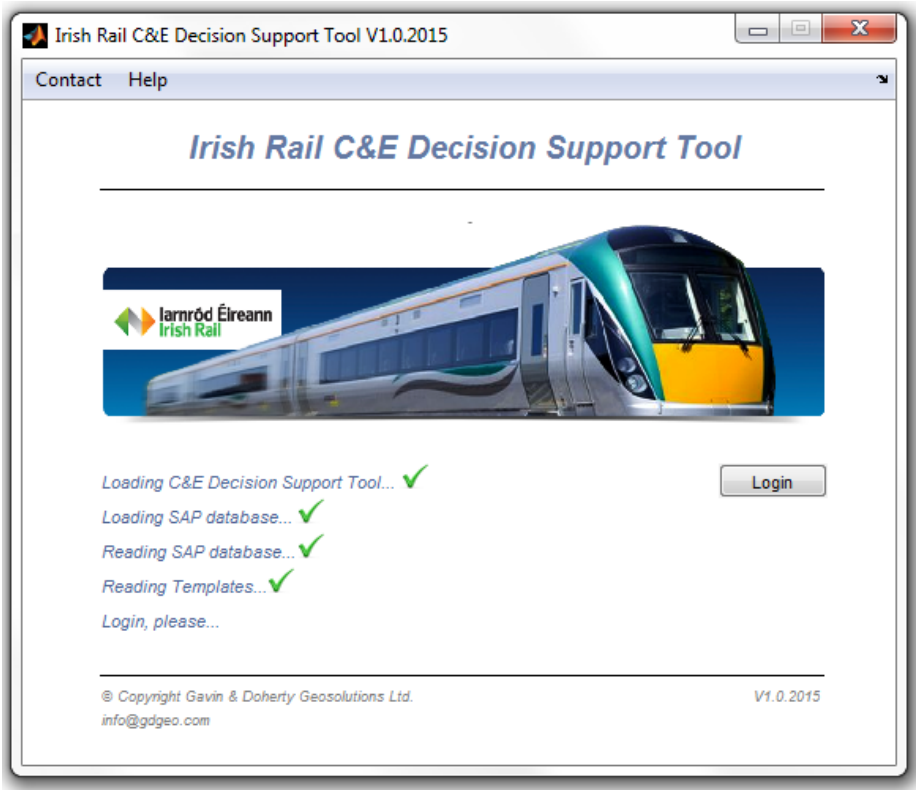
STAGE 2: REFINE GUI



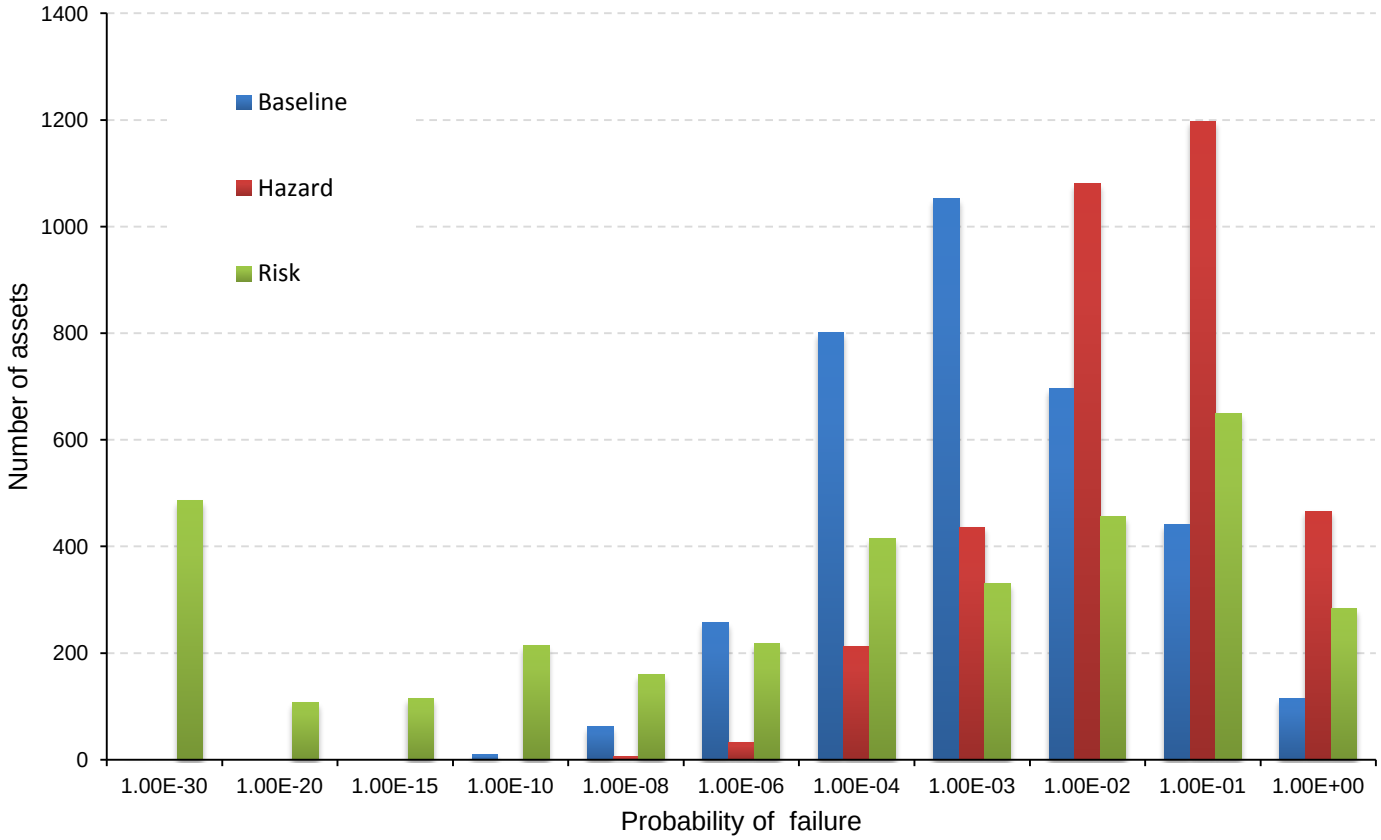
Risk Model Development

STAGE 3

- Asset risk values are obtained.
- Tool's in-built slope asset management plan gives generic remediation and mitigation strategies for slopes with different risk profiles.
- A **cost benefit analysis tool** as an independent module is used in parallel with the slope management plan to inform decisions on where expenditure should be focused.



Risk Model Output



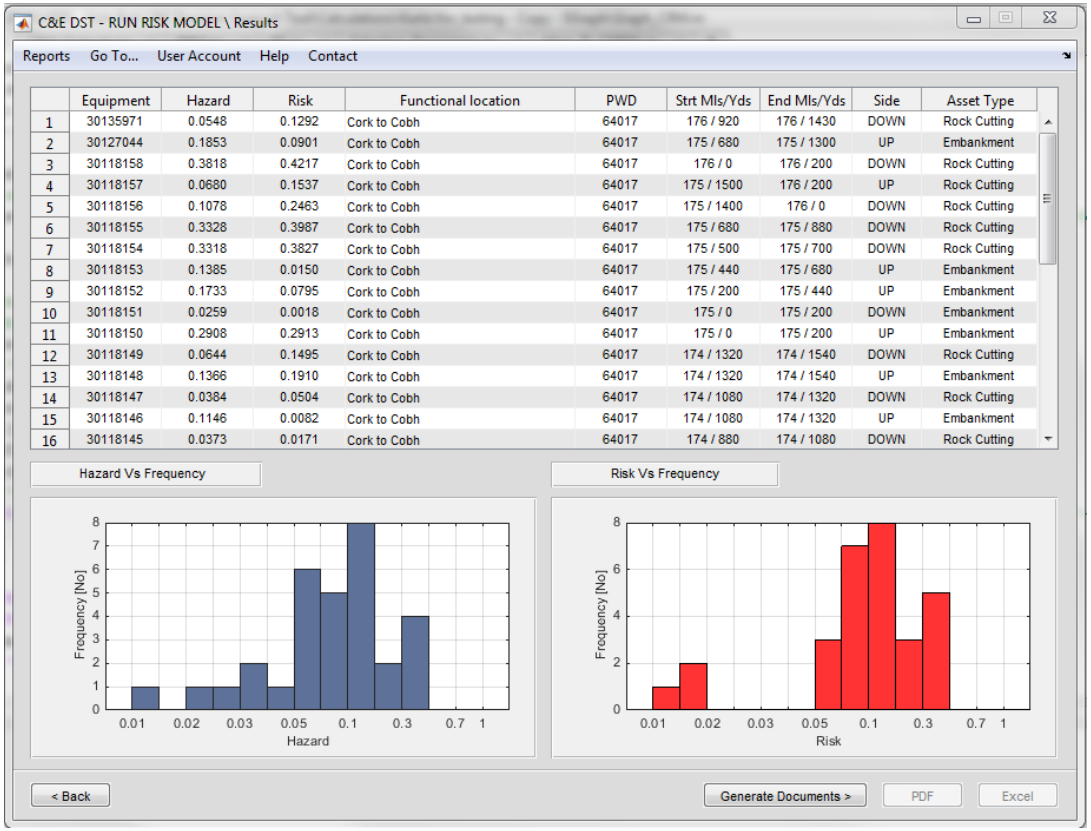
Final distribution of Pfs for baseline, hazard and risk

Outputs validated against known hotspots!

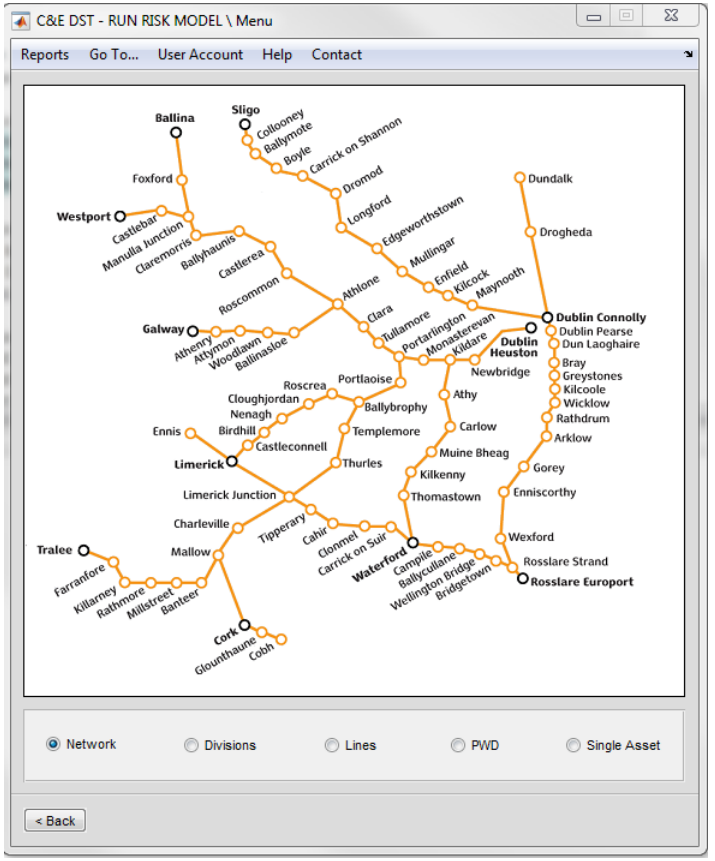
Risk Model Output

GUI – intuitive, versatile, interrogation options

- Possibilities for output: Excel, graphical, PDF. Automatic report-making



	Equipment	Hazard	Risk	Functional location	PWD	Strt Mls/Yds	End Mls/Yds	Side	Asset Type
1	30135971	0.0548	0.1292	Cork to Cobh	64017	176 / 920	176 / 1430	DOWN	Rock Cutting
2	30127044	0.1853	0.0901	Cork to Cobh	64017	175 / 680	175 / 1300	UP	Embankment
3	30118158	0.3818	0.4217	Cork to Cobh	64017	176 / 0	176 / 200	DOWN	Rock Cutting
4	30118157	0.0680	0.1537	Cork to Cobh	64017	175 / 1500	176 / 200	UP	Rock Cutting
5	30118156	0.1078	0.2463	Cork to Cobh	64017	175 / 1400	176 / 0	DOWN	Rock Cutting
6	30118155	0.3328	0.3987	Cork to Cobh	64017	175 / 680	175 / 880	DOWN	Rock Cutting
7	30118154	0.3318	0.3827	Cork to Cobh	64017	175 / 500	175 / 700	DOWN	Rock Cutting
8	30118153	0.1385	0.0150	Cork to Cobh	64017	175 / 440	175 / 680	UP	Embankment
9	30118152	0.1733	0.0795	Cork to Cobh	64017	175 / 200	175 / 440	UP	Embankment
10	30118151	0.0259	0.0018	Cork to Cobh	64017	175 / 0	175 / 200	DOWN	Embankment
11	30118150	0.2908	0.2913	Cork to Cobh	64017	175 / 0	175 / 200	UP	Embankment
12	30118149	0.0644	0.1495	Cork to Cobh	64017	174 / 1320	174 / 1540	DOWN	Rock Cutting
13	30118148	0.1366	0.1910	Cork to Cobh	64017	174 / 1320	174 / 1540	UP	Embankment
14	30118147	0.0384	0.0504	Cork to Cobh	64017	174 / 1080	174 / 1320	DOWN	Rock Cutting
15	30118146	0.1146	0.0082	Cork to Cobh	64017	174 / 1080	174 / 1320	UP	Embankment
16	30118145	0.0373	0.0171	Cork to Cobh	64017	174 / 880	174 / 1080	DOWN	Rock Cutting



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Conclusions

- Detailed asset characteristics defined for all earthworks
- Network wide risk model developed
- Analysis based on probabilistic models with coupled limit states
- Incorporates historical experience and anecdotal factors
- Output is a user friendly piece of software for use as a decision support tool

Acknowledgements

- The following people were instrumental in developing the tool:
  - From Irish Rail: Sharon Callanan, Cathal Mangan, and Cathal Bowe
  - From GDG: Karlo Martinovic, Lin Zhang, Cormac Reale, Ken Gavin