On Application of Systems Dependability Engineering in Design for Cold Climate Compatibility

A case study of wind turbine system

Winterwind2011
Wind energy in low temperature and icing conditions

Idriss El-Thalji
Anders Karlsson &
Egon Leonhardsen

Linnæus University

Statoil

UMEÅ, SWEDEN
February 9-10 2011

Agenda

- Motivations & Research needs
- Design for cold climate compatibility (DCCC)
- Case study and Site experiences
- Cold climate influences
- Technological solutions
- Incident codification system and e-cold climate dependability database
- Asset Simulated assessment of technological solution
- Recommendations for cold climate stakeholders

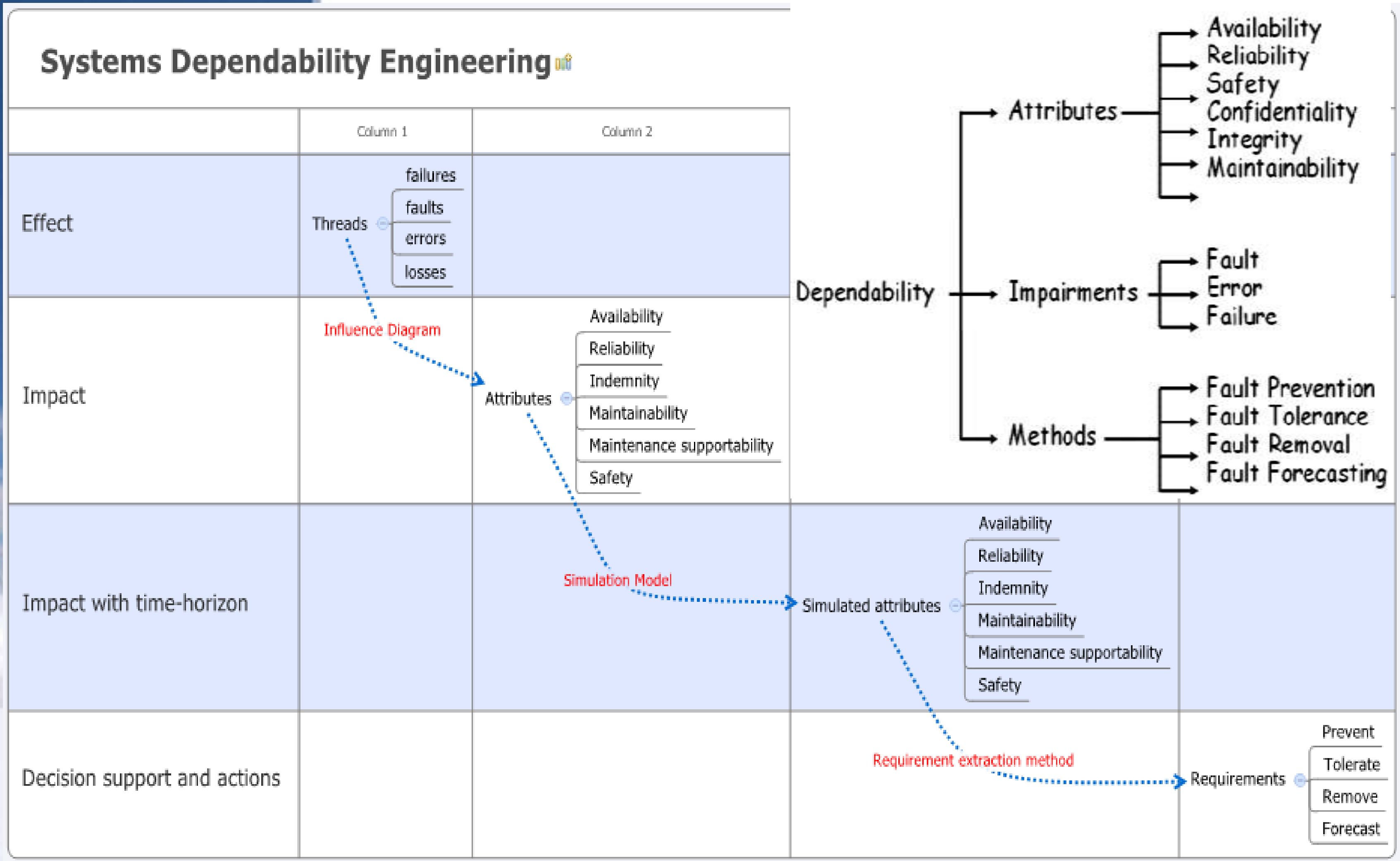
Motivations & Research needs

- High wind availability
- Less visual impacts
- More public acceptance

What are dependability threads due to CC?

- Cold climate condition impact physical systems
- Impact operational & maintenance practices
- Impact supportive practices

SysDE with focus on Design for Cold Climate Compatibility



Dependability ?

How we measure the dependability in terms of cost?

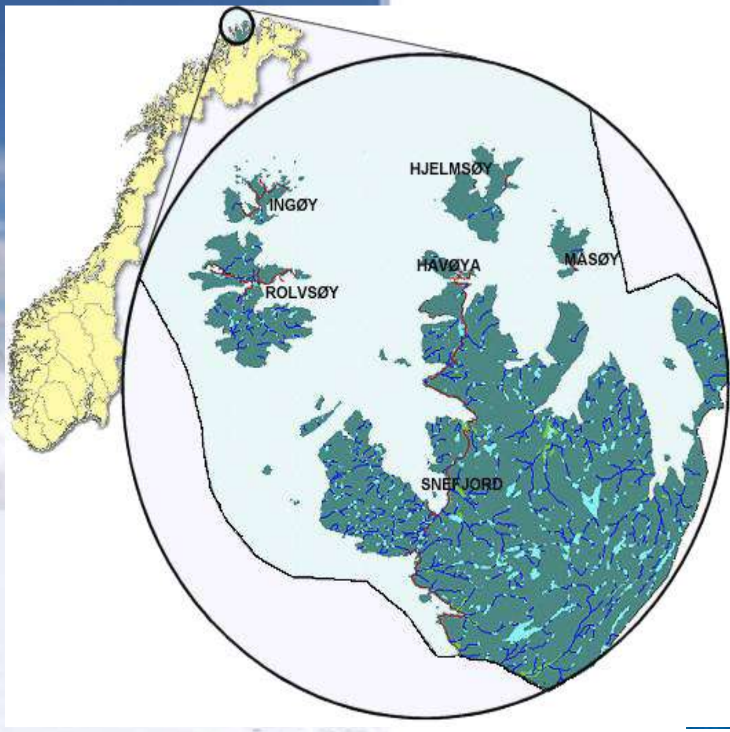
- Production losses
- Direct operation & support cost

How we improve dependability of wind farm?

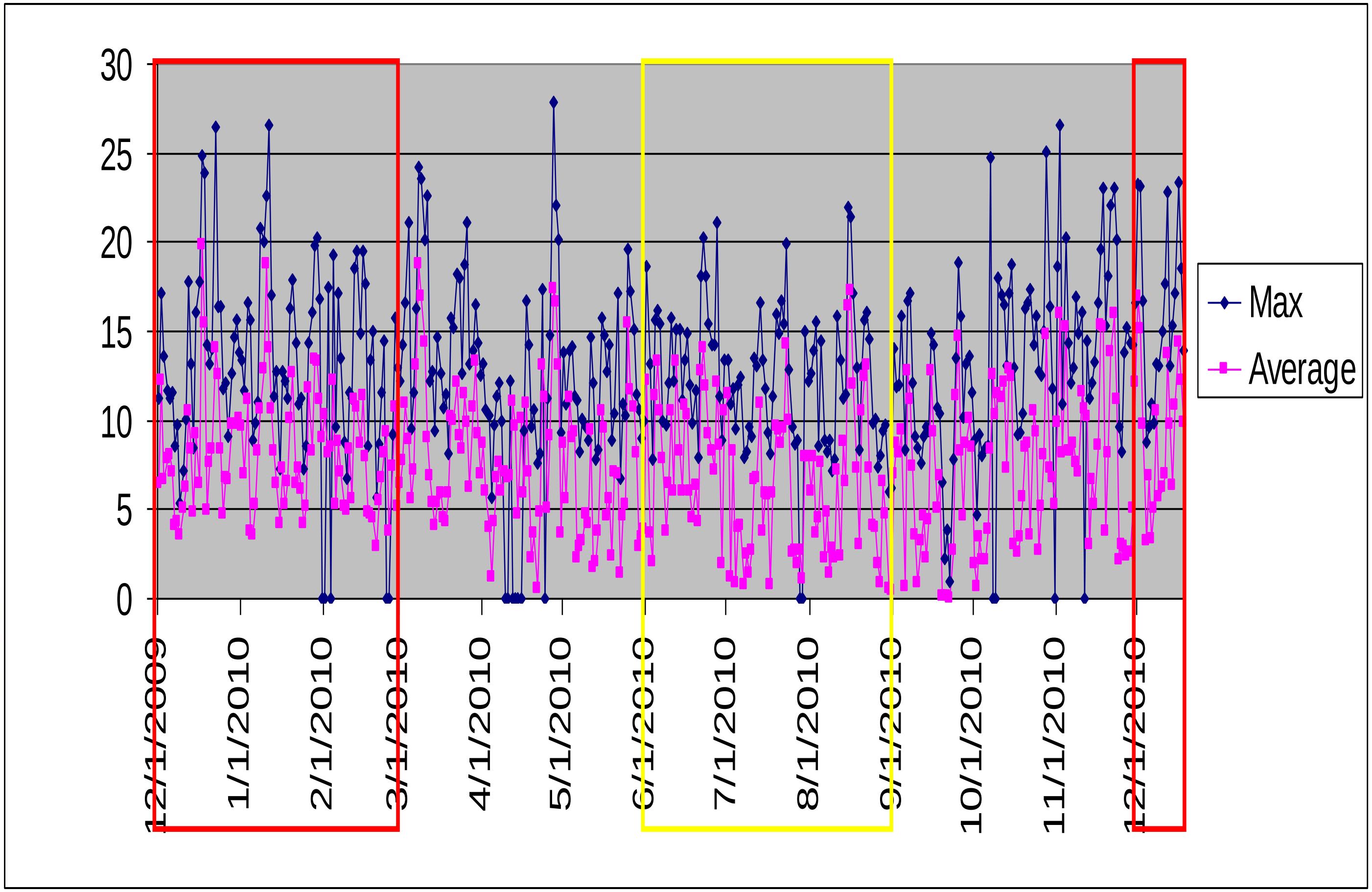
- Increase reliability
- Increase maintainability
- Increase maintenance supportability

Case Wind Farm

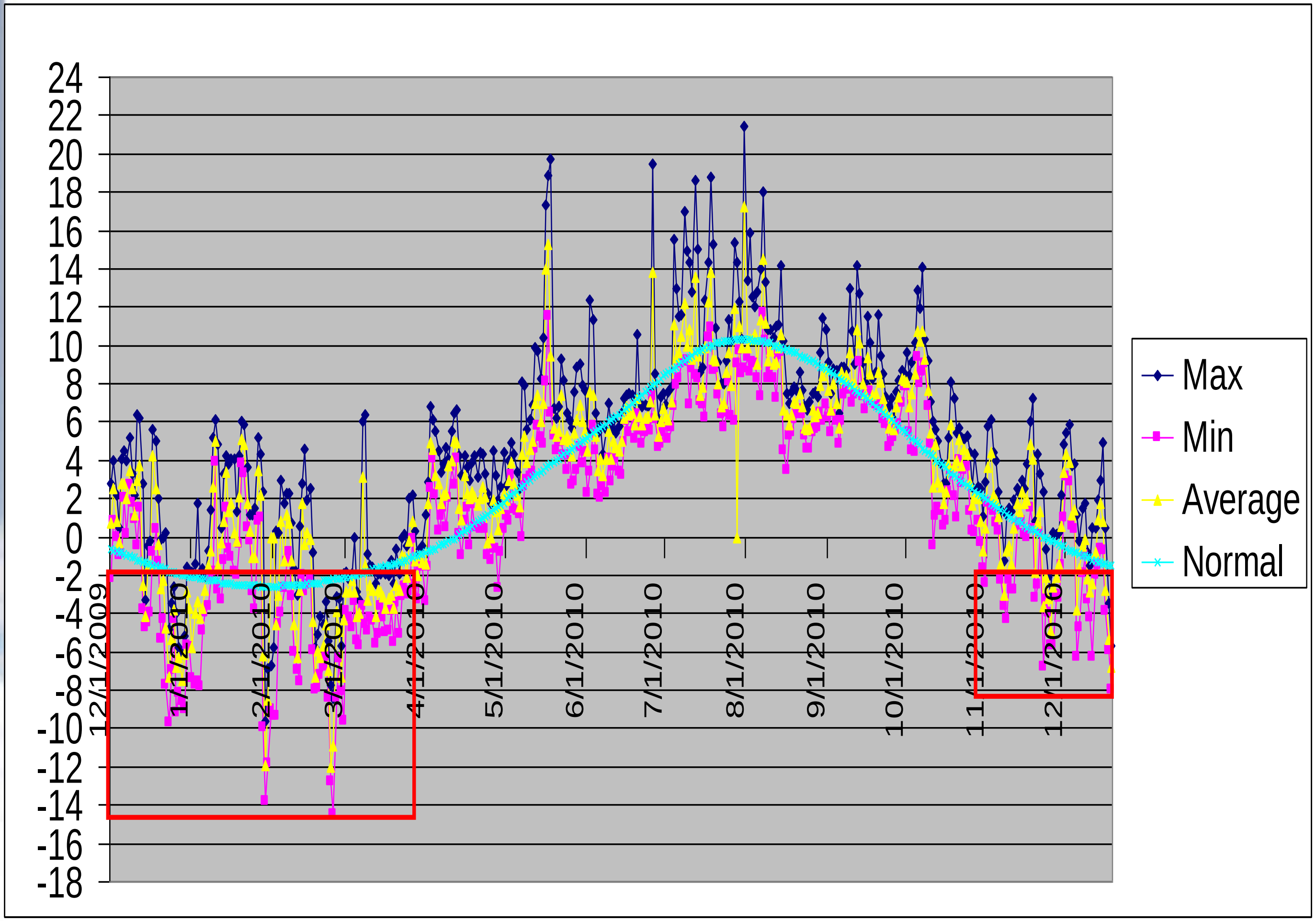
- The Havøygavlen windmill park officially opened on 4 June 2003 in northern Norway in the Måsøy municipality in Finnmark. The park is 180km northeast of Hammerfest, and cost a total of NOK336 million ($44 million).



Site wind speed



Site temperature



Technical aspects

Turbine:15 X and 1 Y (direct drive)
The wind speed reaches the 30 m/s
The there three technician of X company
The control depend on SCADA system
The plan is to install the CMS

2003 operations start
2004/2005 all gearboxes changed

site technical issues

The main effect of winter weather is the north wind
Otherwise the south west wind is idle for operation

Temperature in winter is about 0 to -16, average is -10

Salty wind from the sea (Corrosion in blade covers, tower flanges)

Lubrication oil inspection every 6 months and oil change every three years

Operating temperature and oil heater

Impacts on Pitch system due to high wind turbulence and dust, the change in design of hardware and software to cope with weather condition and better controlling

The capacitors are old after 7 years and they needed to be changed

Azimuth system, updated for new motors and controller

Generator only one bearing changed

Winter storm----stop-----then oil become thinker-------needed more extra heating load to reach the needed viscosity after start up

Maintenance practices

Firstly, it was two visits in winter and summer, but because the production losses and work difficulties it change

New way:
The maintenance visit should be performed between May and September with two types of maintenance packages: small (30 hr) and large scale (50-60) for each wind turbine

Small scale maintenance including inspection and defining the problems for large scale maintenance

Large scale maintenance including oil change, replace & repair

The dark problem affect the workforce performance
http://www.arctic.noaa.gov/np2003/gallery_np_tour.html

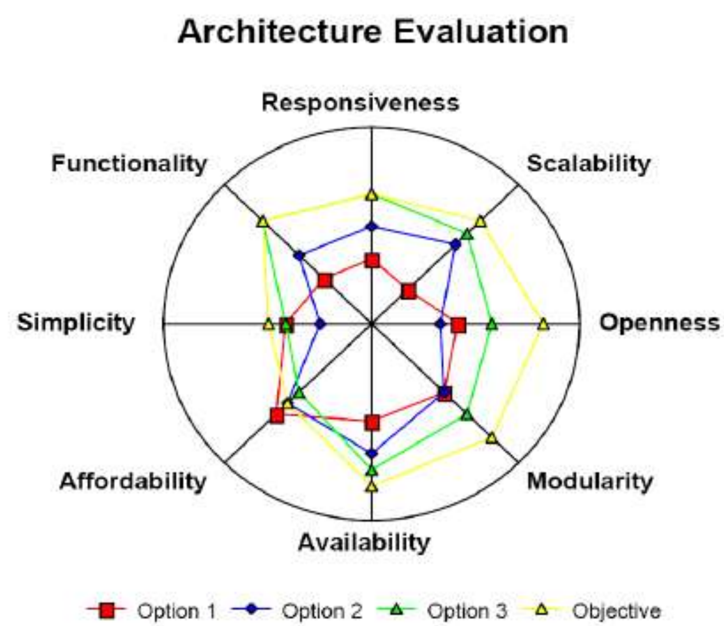
Spare part: policy is to have at least one turbine as spare part
With logistic time of 7-10 from Germany through Sweden by truck

Technological solution space

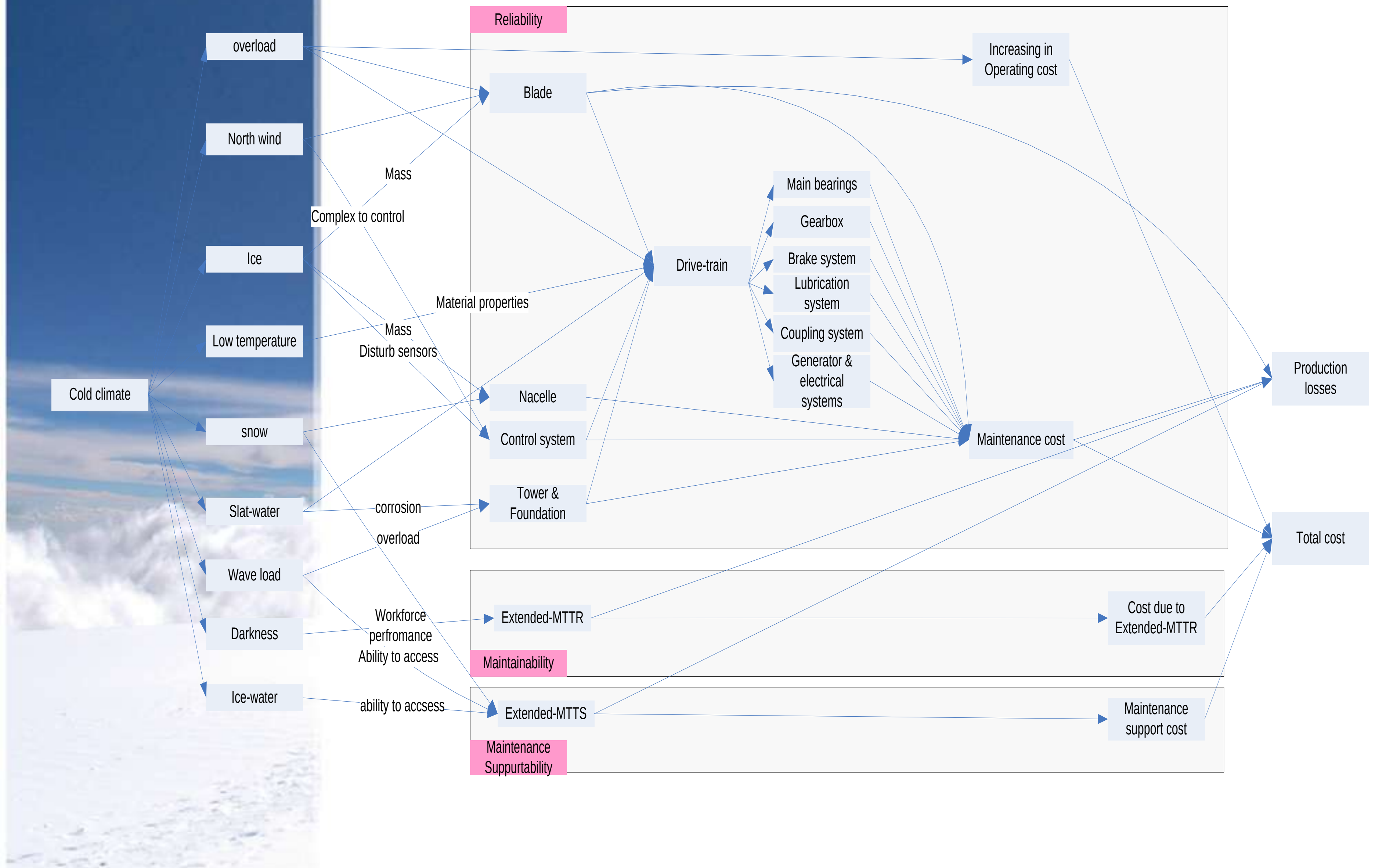
1. Ice detectors: to detect ice, ice accretion phase, and its total time, ice structure.
2. Anti-and de-icing technology
3. Low temperature solutions
4. Wind sensors
5. Site supportive equipments like mobiles, bulldozers, cranes, infrastructure
6. Human factor/ ergonomics for operators and maintenance staff

Challenges

High cost & affordability
Uncertainty
Interoperability
Scalability

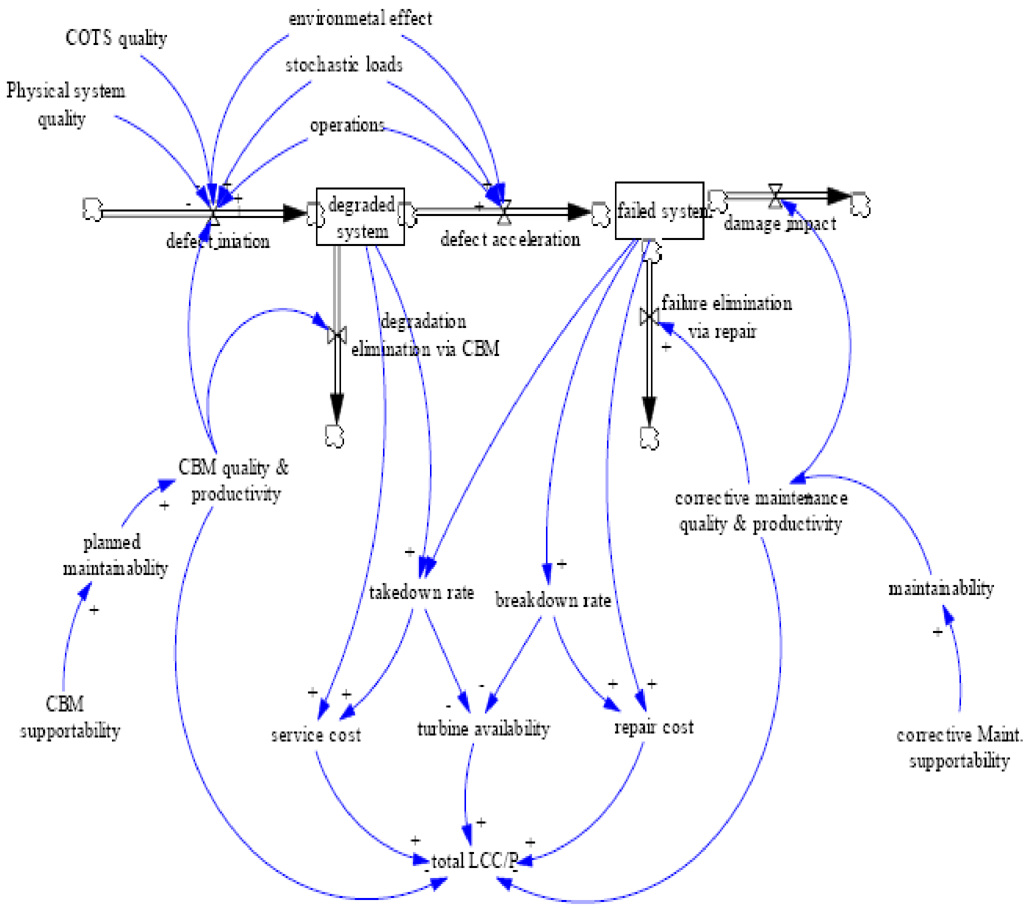


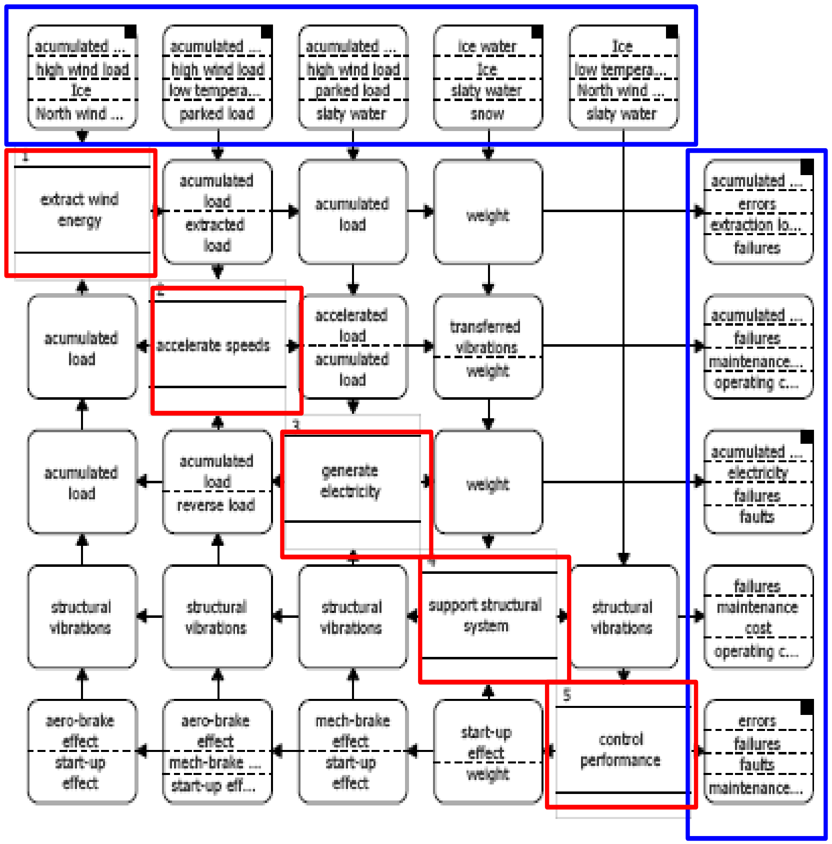
Influence diagram of cold climate conditions



Winter storm scenario & systems dynamic model

----stop-----then oil become thicker-------needed more extra heating load to reach the needed viscosity after start up





Coding system for dependability threads

Codify the incident reports provide ability to:

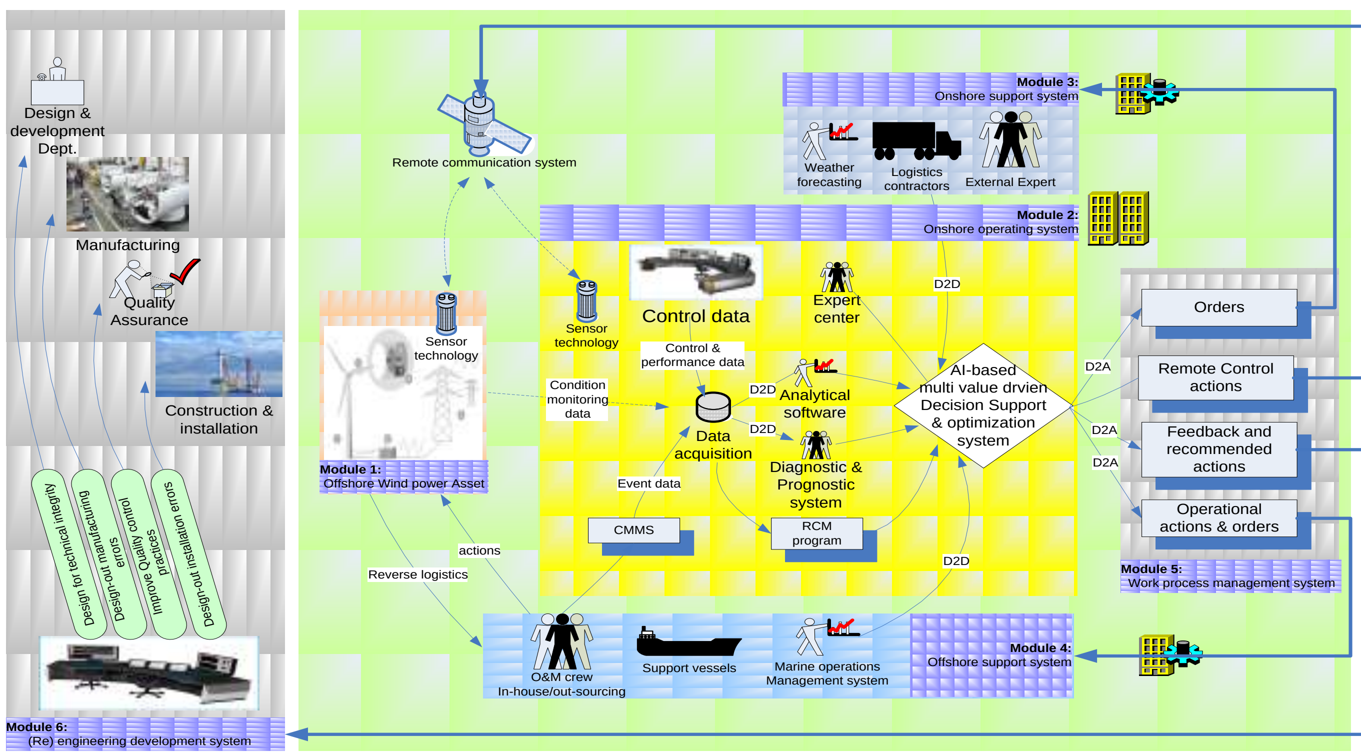
-Determine event circumstances

-Define critical threads and prioritize available technological solutions

-better action and maintenance planning

-Reduce operation & maintenance errors

-Self-generated requirements for improvements



Coding system for dependability threads

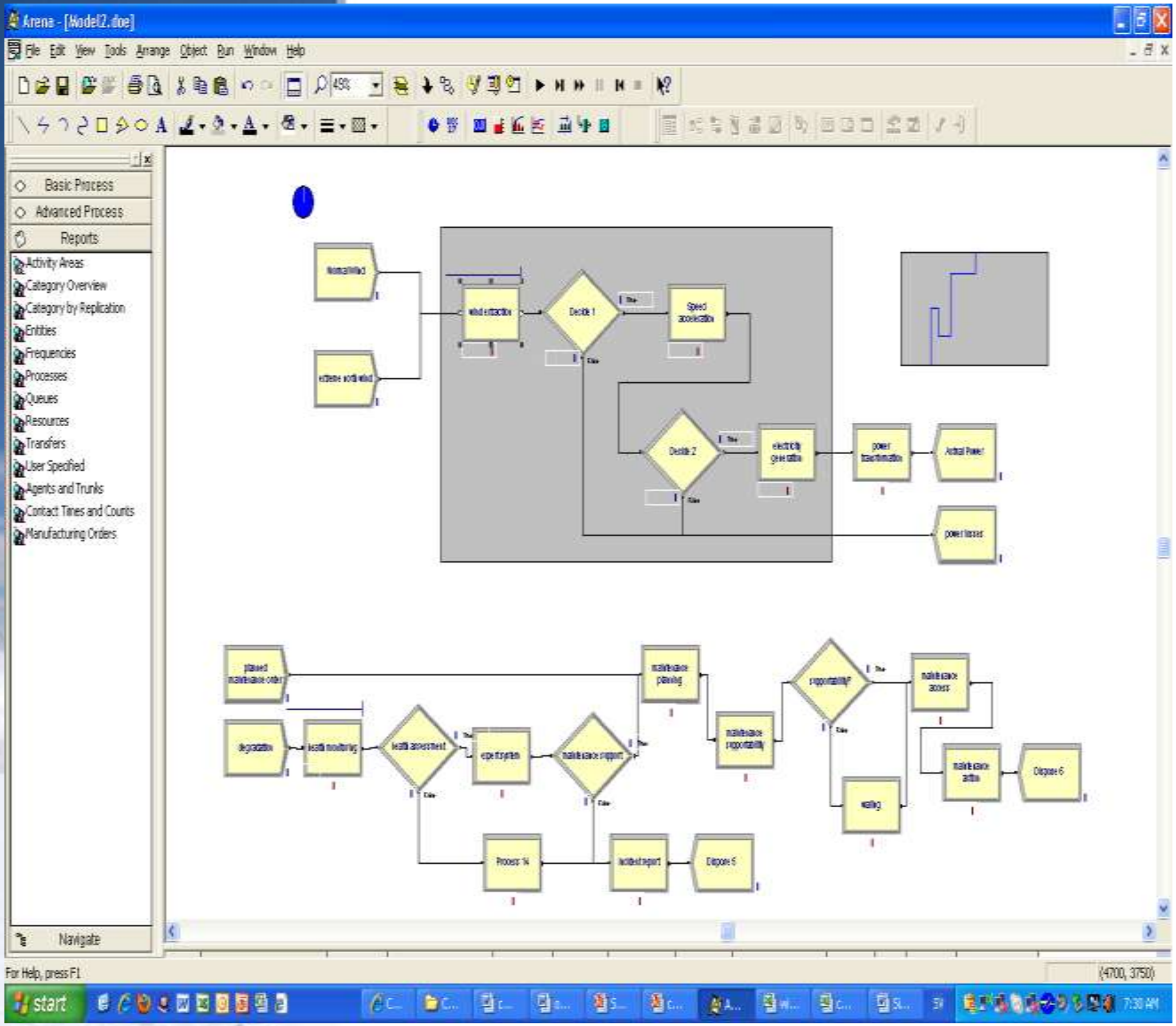
Incident report code includes
-Event data
-Context data and information of incident event
-Technical data and classification
-Failure mode, cause, pattern data
-Acting procedures and recommendations

CODE	operating status		site conditions		seasonal conditions		incident type		thread type
R	running with 100%	AV	wind speed average	I	ice	V	Vibration TAC84	F	failure
80R	running with 80%	X12	extreme wind speed (> 12 m/s)	S	snow	UP	Unbalanced pitch	I	fault
50R	running with 50%	XXX	specific wind speed pattern	LT	temperature	VD	Vibration TAC84 downwind	E	operating error
SS	short stop	O25	over 25 m/s	NW	north wind	PS	planned stop	ME	maintenance error
DT	downtime			WS	storms	PD	planned performance degradation	L	losses
						pD	performance degradation		
						F	Extreme flap moment protection		
						Y	EFM yaw error too high		
						S	Wind sensor right fault		
						AF	Anemometer 1 fault		

CODE	failed component		failure cause		failure event charactertics		incident impact
BX	blade	D	design	VL	vibration load	TTD	time to detect
MB	main bearing	OL	overload	TO	operating temperature	TD	time to take decision
R	rotor shaft	S	stochastic load	SL	stress load	TTS	time to support
GB	gearbox	XC	extreme duty cycle	V	lubrication viscosity	TTA	time to access
C	coupling	WH	working hour	LL	lubrication cleanness	TTM	time to maintain
BX	brake system			E	elasticity of material		
G	generator						
T	transformer						

CODE	maintenance type		access type
IS	inspection	T	truck
R	replacement	HVS	heavy support vehicle
RQ	retorque	SV	support vessel
RIN	repair on site	J	jack-up
ROUT	repair off-site		

Simulation package



Simulation model:

-Wind turbine production and losses

-Operation & maintenance system

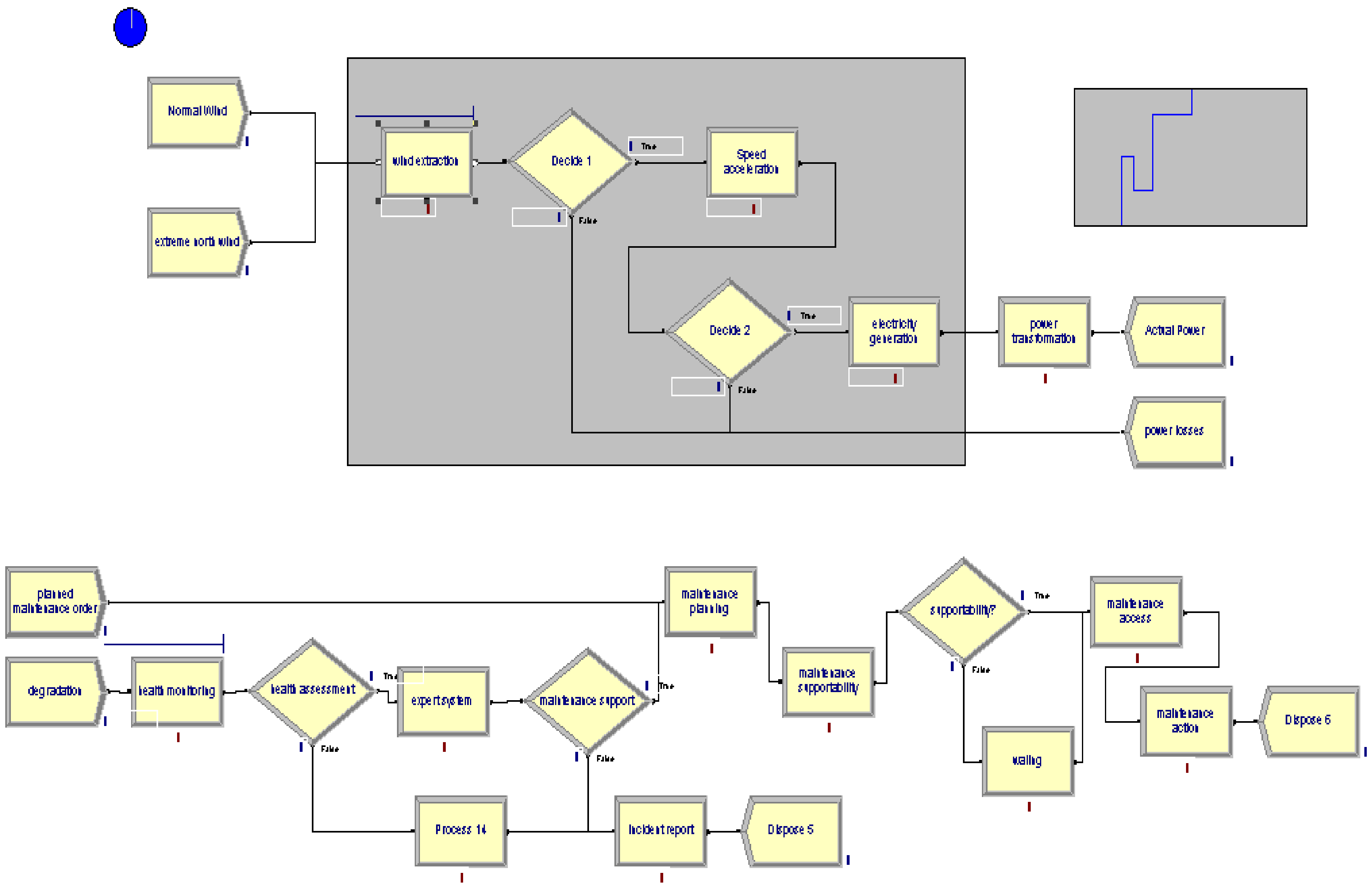
-Lifetime simulation

-Reporting life cycle costs

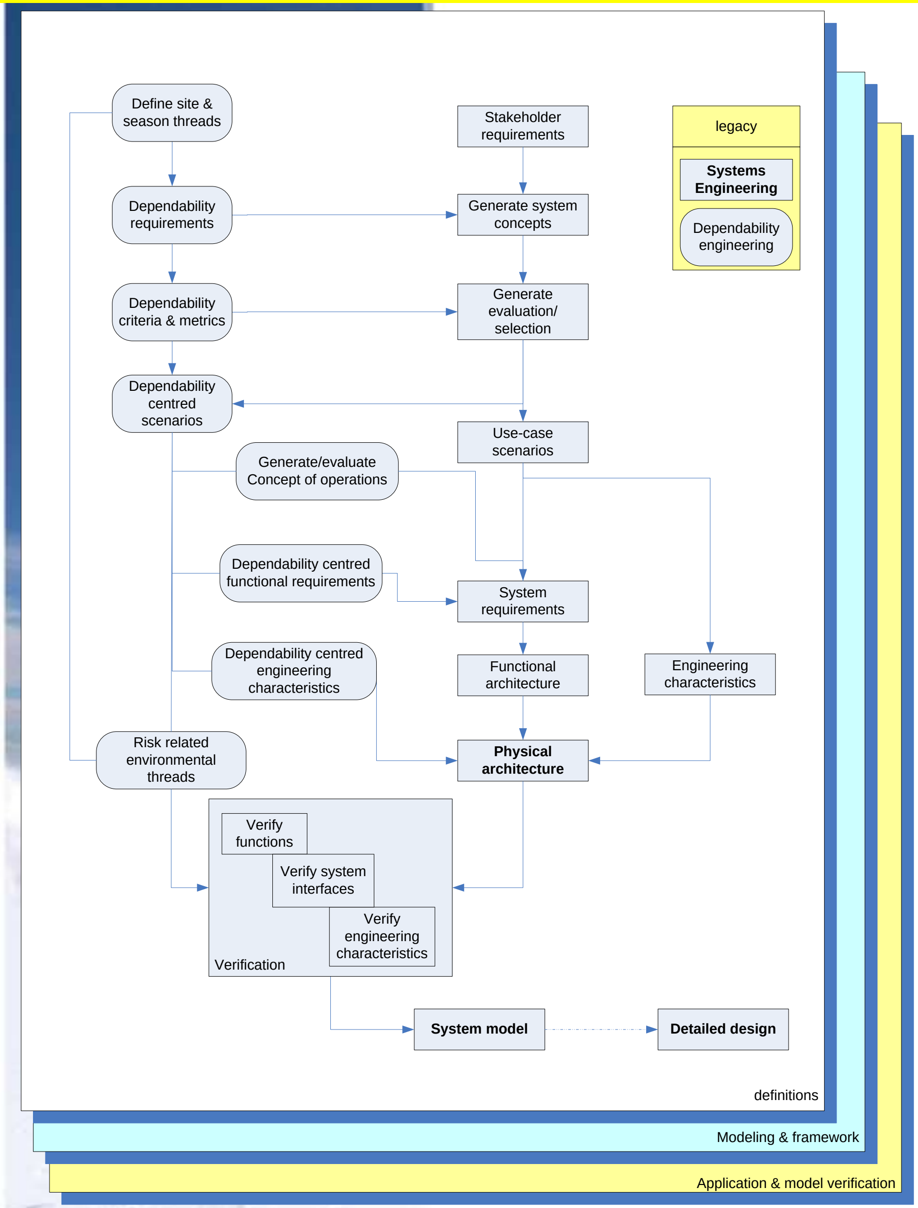
-Shows effect of cold climate condition on overall asset

-Shows the enhancement of new add-on system, operating scenario

Simulation model of the asset dependability plan



Overall methodology of 'design for cold climate compatibility'



- There are a lot of system requirement behind use-case scenarios
- Simulation is an helpful tool to estimate the power production, losses and maintenance process.
- Adding-on technology into engineering architecture it is an iterative process
- System scale could impact the dependability of system-of-interest

recommendation

For manufacturer

- System Requirement Review (SRR) should include
dependability plan based on site & seasonal conditions
of installation site.
- Cold climate impact it is not ice and low temperature and needed to visualize in a sub-system levels
- Scale of system and application site are the context of our experience
- The new technological solutions needed to be assessed based on overall system effectiveness criteria

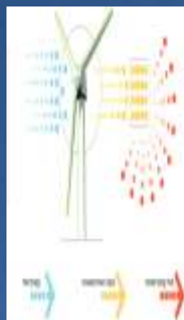
For operating & support

- Commercial on the shelf (COTS) should be assessed for the specific installation site conditions
- RAMS or dependability simulation provide practical meaning of design specification in the design phase.
- Coding incident report/events reduce errors, better understanding of event, faster support process planning and self-generated improvement requirements

For consultant company

- Dependability model & simulation is an helpful module for site assessment system to assess optimal O&M cost together to wind power production

life cycle stakeholders

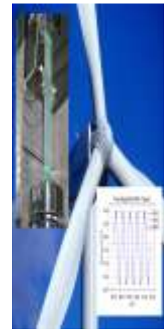


Design & development system

Manufacturing system

Logistic system

Construction system



Operating system

Maintenance system & Accessing system

Disposal issues

Winterwind2011
Wind energy in low temperature and icing conditions

Thanks a lot

UMEÅ, SWEDEN
February 9-10 2011