$[s_{11}^{(2)}(t,2)]^{(10)}$=exp[−0.04$t$],

$[s_{11}^{(2)}(t,3)]^{(10)}$ = exp[−0.05t],

$[s_{11}^{(2)}(t,4)]^{(10)}$ = exp[−0.055t],

$[s_{12}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{12}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{12}^{(2)}(t,3)]^{(10)}$ = exp[−0.05t],

$[s_{12}^{(2)}(t,4)]^{(10)}$ = exp[−0.055t],

$[s_{13}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{13}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{13}^{(2)}(t,3)]^{(10)}$ = exp[−0.05t],

$[s_{13}^{(2)}(t,4)]^{(10)}$ = exp[−0.055t],

$[s_{14}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{14}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{14}^{(2)}(t,3)]^{(10)}$ = exp[−0.05t],

$[s_{14}^{(2)}(t,4)]^{(10)}$ = exp[−0.055t],

$[s_{21}^{(2)}(t,1)]^{(10)}$ = exp[−0.066t],

$[s_{21}^{(2)}(t,2)]^{(10)}$ = exp[−0.07t],

$[s_{21}^{(2)}(t,3)]^{(10)}$ = exp[−0.075t],

$[s_{21}^{(2)}(t,4)]^{(10)}$ = exp[−0.08t],

$[s_{22}^{(2)}(t,1)]^{(10)}$ = exp[−0.066t],

$[s_{22}^{(2)}(t,2)]^{(10)}$ = exp[−0.07t],

$[s_{22}^{(2)}(t,3)]^{(10)}$ = exp[−0.075t],

$[s_{22}^{(2)}(t,4)]^{(10)}$ = exp[−0.08t],

$[s_{31}^{(2)}(t,1)]^{(10)}$ = exp[−0.066t],

$[s_{31}^{(2)}(t,2)]^{(10)}$ = exp[−0.07t],

$[s_{31}^{(2)}(t,3)]^{(10)}$ = exp[−0.075t],

$[s_{31}^{(2)}(t,4)]^{(10)}$ = exp[−0.08t],

$[s_{41}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{41}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{41}^{(2)}(t,3)]^{(10)}$ = exp[−0.045t],

$[s_{41}^{(2)}(t,4)]^{(10)}$ = exp[−0.05t],

$[s_{51}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{51}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{51}^{(2)}(t,3)]^{(10)}$ = exp[−0.045t],

$[s_{51}^{(2)}(t,4)]^{(10)}$ = exp[−0.05t],

$[s_{61}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{61}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{61}^{(2)}(t,3)]^{(10)}$ = exp[−0.045t],

$[s_{61}^{(2)}(t,4)]^{(10)}$ = exp[−0.05t],

$[s_{71}^{(2)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{71}^{(2)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{71}^{(2)}(t,3)]^{(10)}$ = exp[−0.045t],

$[s_{71}^{(2)}(t,4)]^{(10)}$ = exp[−0.05t].

The subsystem S_5 consist of components $E_{11}^{(5)}$, $E_{21}^{(5)}$, $E_{31}^{(5)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(5)}(t,1)]^{(10)}$ = exp[−0.033t],

$[s_{11}^{(5)}(t,2)]^{(10)}$ = exp[−0.04t],

$[s_{11}^{(5)}(t,3)]^{(10)}$ = exp[−0.045t],

$[s_{11}^{(5)}(t,4)]^{(10)} = \exp[-0.05t]$,

$[s_{21}^{(5)}(t,1)]^{(10)} = \exp[-0.033t]$,

$[s_{21}^{(5)}(t,2)]^{(10)} = \exp[-0.04t]$,

$[s_{21}^{(5)}(t,3)]^{(10)} = \exp[-0.05t]$,

$[s_{21}^{(5)}(t,4)]^{(10)} = \exp[-0.055t]$,

$[s_{31}^{(5)}(t,1)]^{(10)} = \exp[-0.033t]$,

$[s_{31}^{(5)}(t,2)]^{(10)} = \exp[-0.04t]$,

$[s_{31}^{(5)}(t,3)]^{(10)} = \exp[-0.05t]$,

$[s_{31}^{(5)}(t,4)]^{(10)} = \exp[-0.06t]$.

At the operation states z_{11}, i.e. at the ship turning state the ferry is built of $n_{11} = 2$ subsystems S_1 and S_2 forming a series structure shown in *Figure 23*.

The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(11)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(11)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{21}^{(2)}$, $E_{22}^{(2)}$, $E_{31}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(11)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(11)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(11)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(11)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(11)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(11)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(11)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(11)} = \exp[-0.055t]$,

$[s_{21}^{(2)}(t,1)]^{(11)} = \exp[-0.066t]$,

$[s_{21}^{(2)}(t,2)]^{(11)} = \exp[-0.07t]$,

$[s_{21}^{(2)}(t,3)]^{(11)} = \exp[-0.075t]$,

$[s_{21}^{(2)}(t,4)]^{(11)} = \exp[-0.08t]$,

$[s_{22}^{(2)}(t,1)]^{(11)} = \exp[-0.066t]$,

$[s_{22}^{(2)}(t,2)]^{(11)} = \exp[-0.074t]$,

$[s_{22}^{(2)}(t,3)]^{(11)} = \exp[-0.075t]$,

$[s_{22}^{(2)}(t,4)]^{(11)} = \exp[-0.08t]$,

$[s_{31}^{(2)}(t,1)]^{(11)} = \exp[-0.066t]$,

$[s_{31}^{(2)}(t,2)]^{(11)} = \exp[-0.07t]$,

$[s_{31}^{(2)}(t,3)]^{(11)} = \exp[-0.075t]$,

$[s_{31}^{(2)}(t,4)]^{(11)} = \exp[-0.08t]$,

$[s_{41}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(11)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(11)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(11)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(11)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(11)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(11)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(11)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(11)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(11)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(11)} = \exp[-0.05t]$.

At the operation states z_{12}, i.e. at the leaving Karlskrona Port state the ferry is built of $n_{12} = 3$ subsystems S_1, S_2 and S_4 forming a series structure shown in *Figure 24*.
The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(12)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(12)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(12)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(12)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(12)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(12)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(12)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(12)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(12)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(12)} = \exp[-0.055t]$,

$[s_{41}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(12)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(12)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(12)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(12)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(12)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(12)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(12)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(12)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(12)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(12)} = \exp[-0.05t]$.

The subsystem S_4 consist of component $E_{11}^{(4)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(4)}(t,1)]^{(12)} = \exp[-0.05t]$,

$[s_{11}^{(3)}(t,2)]^{(12)} = \exp[-0.06t]$,

$[s_{11}^{(3)}(t,3)]^{(12)} = \exp[-0.065t]$,

$[s_{11}^{(3)}(t,4)]^{(12)} = \exp[-0.07t]$.

At the operation states z_{13}, i.e. at the navigation at open waters state the ferry is built of $n_{13} = 3$ subsystems S_1, S_2 and S_4 forming a series structure shown in *Figure 25*.

The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(13)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(13)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(13)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(13)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(13)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(13)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(13)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(13)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(13)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(13)} = \exp[-0.055t]$,

$[s_{41}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(13)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(13)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(13)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(13)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(13)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(13)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(13)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(13)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(13)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(13)} = \exp[-0.05t]$.

The subsystem S_4 consist of component $E_{11}^{(4)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(4)}(t,1)]^{(13)} = \exp[-0.05t]$,

$[s_{11}^{(3)}(t,2)]^{(13)} = \exp[-0.06t]$,

$[s_{11}^{(3)}(t,3)]^{(13)} = \exp[-0.065t]$,

$[s_{11}^{(3)}(t,4)]^{(13)} = \exp[-0.07t]$.

At the operation states z_{14}, i.e. at the navigation at restricted waters state the ferry is built of $n_{14} = 3$ subsystems S_1, S_2 and S_4 forming a series structure shown in *Figure 26*.

The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(14)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(14)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(14)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(14)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(14)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(14)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(14)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(14)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(14)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(14)} = \exp[-0.055t]$,

$[s_{41}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(14)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(14)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(14)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(14)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(14)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(14)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(14)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(14)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(14)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(14)} = \exp[-0.05t]$.

The subsystem S_4 consist of component $E_{11}^{(4)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(4)}(t,1)]^{(14)} = \exp[-0.05t]$,

$[s_{11}^{(4)}(t,2)]^{(14)} = \exp[-0.06t]$,

$[s_{11}^{(4)}(t,3)]^{(14)} = \exp[-0.065t]$,

$[s_{11}^{(4)}(t,4)]^{(14)} = \exp[-0.07t]$.

At the operation states z_{15}, i.e. at the navigation to turning area state the ferry is built of $n_{15} = 2$ subsystems S_1 and S_2 forming a series structure shown in *Figure 27*.
The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(15)} = \exp[-0.045t]$,
$[s_{11}^{(1)}(t,4)]^{(15)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{21}^{(2)}$, $E_{22}^{(2)}$, $E_{31}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(15)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(15)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(15)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(15)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(15)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(15)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(15)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(15)} = \exp[-0.055t]$,

$[s_{21}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{21}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{21}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{21}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{22}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,
$[s_{22}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{22}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{22}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{31}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{31}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{31}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{31}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{41}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(15)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(15)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(15)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(15)} = \exp[-0.05t]$.

At the operation states z_{16}, i.e. at the ship turning state the ferry is built of $n_{16} = 2$ subsystems S_1 and S_2 forming a series structure shown in *Figure 28.*

The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(16)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(16)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{21}^{(2)}$, $E_{22}^{(2)}$, $E_{31}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(16)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(16)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(16)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(16)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(16)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(16)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(16)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(16)} = \exp[-0.055t]$,

$[s_{21}^{(2)}(t,1)]^{(16)} = \exp[-0.066t]$,

$[s_{21}^{(2)}(t,2)]^{(16)} = \exp[-0.07t]$,

$[s_{21}^{(2)}(t,3)]^{(16)} = \exp[-0.075t]$,

$[s_{21}^{(2)}(t,4)]^{(16)} = \exp[-0.08t]$,

$[s_{22}^{(2)}(t,1)]^{(16)} = \exp[-0.066t]$,

$[s_{22}^{(2)}(t,2)]^{(16)} = \exp[-0.07t]$,

$[s_{22}^{(2)}(t,3)]^{(16)} = \exp[-0.075t]$,

$[s_{22}^{(2)}(t,4)]^{(16)} = \exp[-0.08t]$,

$[s_{31}^{(2)}(t,1)]^{(16)} = \exp[-0.066t]$,

$[s_{31}^{(2)}(t,2)]^{(16)} = \exp[-0.07t]$,

$[s_{31}^{(2)}(t,3)]^{(16)} = \exp[-0.075t]$,

$[s_{31}^{(2)}(t,4)]^{(16)} = \exp[-0.08t]$,

$[s_{41}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(16)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(16)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(16)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(16)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(16)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(16)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(16)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(16)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(16)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(16)} = \exp[-0.05t]$.

At the operation states z_{17}, i.e. at the mooring operations state the ferry is built of $n_{17} = 3$ subsystems S_1, S_2 and S_5 forming a series structure shown in *Figure 29*.

The subsystem S_1 consist of component $E_{11}^{(1)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(1)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{11}^{(1)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{11}^{(1)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{11}^{(1)}(t,4)]^{(17)} = \exp[-0.05t]$.

The subsystem S_2 consist of components $E_{11}^{(2)}$, $E_{12}^{(2)}$, $E_{13}^{(2)}$, $E_{14}^{(2)}$, $E_{21}^{(2)}$, $E_{22}^{(2)}$, $E_{31}^{(2)}$, $E_{41}^{(2)}$, $E_{51}^{(2)}$, $E_{61}^{(2)}$, $E_{71}^{(2)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{11}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{11}^{(2)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{11}^{(2)}(t,4)]^{(17)} = \exp[-0.055t]$,

$[s_{12}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{12}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{12}^{(2)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{12}^{(2)}(t,4)]^{(17)} = \exp[-0.055t]$,

$[s_{13}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{13}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{13}^{(2)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{13}^{(2)}(t,4)]^{(17)} = \exp[-0.055t]$,

$[s_{14}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{14}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{14}^{(2)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{14}^{(2)}(t,4)]^{(17)} = \exp[-0.055t]$,

$[s_{21}^{(2)}(t,1)]^{(17)} = \exp[-0.066t]$,

$[s_{21}^{(2)}(t,2)]^{(17)} = \exp[-0.07t]$,

$[s_{21}^{(2)}(t,3)]^{(17)} = \exp[-0.075t]$,

$[s_{21}^{(2)}(t,4)]^{(17)} = \exp[-0.08t]$,

$[s_{22}^{(2)}(t,1)]^{(17)} = \exp[-0.066t]$,

$[s_{22}^{(2)}(t,2)]^{(17)} = \exp[-0.07t]$,

$[s_{22}^{(2)}(t,3)]^{(17)} = \exp[-0.075t]$,

$[s_{22}^{(2)}(t,4)]^{(17)} = \exp[-0.08t]$,

$[s_{31}^{(2)}(t,1)]^{(17)} = \exp[-0.066t]$,

$[s_{31}^{(2)}(t,2)]^{(17)} = \exp[-0.07t]$,

$[s_{31}^{(2)}(t,3)]^{(17)} = \exp[-0.075t]$,

$[s_{31}^{(2)}(t,4)]^{(17)} = \exp[-0.08t]$,

$[s_{41}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{41}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{41}^{(2)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{41}^{(2)}(t,4)]^{(17)} = \exp[-0.05t]$,

$[s_{51}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{51}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{51}^{(2)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{51}^{(2)}(t,4)]^{(17)} = \exp[-0.05t]$,

$[s_{61}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{61}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{61}^{(2)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{61}^{(2)}(t,4)]^{(17)} = \exp[-0.05t]$,

$[s_{71}^{(2)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{71}^{(2)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{71}^{(2)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{71}^{(2)}(t,4)]^{(17)} = \exp[-0.05t]$.

The subsystem S_5 consist of components $E_{11}^{(5)}$, $E_{21}^{(5)}$, $E_{31}^{(5)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(5)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{11}^{(5)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{11}^{(5)}(t,3)]^{(17)} = \exp[-0.045t]$,

$[s_{11}^{(5)}(t,4)]^{(17)} = \exp[-0.05t]$,

$[s_{21}^{(5)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{21}^{(5)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{21}^{(5)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{21}^{(5)}(t,4)]^{(17)} = \exp[-0.055t]$,

$[s_{31}^{(5)}(t,1)]^{(17)} = \exp[-0.033t]$,

$[s_{31}^{(5)}(t,2)]^{(17)} = \exp[-0.04t]$,

$[s_{31}^{(5)}(t,3)]^{(17)} = \exp[-0.05t]$,

$[s_{31}^{(5)}(t,4)]^{(17)} = \exp[-0.06t]$.

At the operation states z_{18}, i.e. at the unloading state the ferry is built of $n_{18} = 2$ subsystems S_3 and S_4 forming a series structure shown in *Figure 29*.

The subsystem S_3 consist of components $E_{11}^{(3)}$, $E_{21}^{(3)}$, $E_{31}^{(3)}$ with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(3)}(t,1)]^{(18)} = \exp[-0.2t]$,

$[s_{11}^{(3)}(t,2)]^{(18)} = \exp[-0.3t]$,

$[s_{11}^{(3)}(t,3)]^{(18)} = \exp[-0.35t]$,

$[s_{11}^{(3)}(t,4)]^{(18)} = \exp[-0.4t]$,

$[s_{21}^{(3)}(t,1)]^{(18)} = \exp[-0.2t]$,

$[s_{21}^{(3)}(t,2)]^{(18)} = \exp[-0.25t]$,

$[s_{21}^{(3)}(t,3)]^{(18)} = \exp[-0.3t]$,

$[s_{21}^{(3)}(t,4)]^{(18)} = \exp[-0.4t]$,

$[s_{31}^{(3)}(t,1)]^{(18)} = \exp[-0.033t]$,

$[s_{31}^{(3)}(t,2)]^{(18)} = \exp[-0.04t]$,

$[s_{31}^{(3)}(t,3)]^{(18)} = \exp[-0.045t]$,

$[s_{31}^{(3)}(t,4)]^{(18)} = \exp[-0.05t]$.

The subsystem S_4 consist of component $E_{11}^{(4)}$, with the conditional multi-state safety functions co-ordinates

$[s_{11}^{(4)}(t,1)]^{(18)} = \exp[-0.05t]$,

$[s_{11}^{(4)}(t,2)]^{(18)} = \exp[-0.06t]$,

$[s_{11}^{(4)}(t,3)]^{(18)} = \exp[-0.065t]$,

$[s_{11}^{(4)}(t,4)]^{(18)} = \exp[-0.07t]$,

6. Identification of the components safety models of real complex technical systems – using computer program

The computer program consists of two parts. In the first part, the program allows to estimate unknown parameters of the exponential distributions of the component conditional lifetimes of the complex technical system in the subsets of safety states. This part of the program is based on the methods and algorithms for evaluating unknown parameters, especially the unknown intensities of component departure from the safety state subset presented in [1]. The maximum likelihood method is applied to estimating these intensities, considering different cases of the empirical experiments and including the cases of small number of realizations and non-completed investigations. In the second part, the program allows to verify the hypotheses, that system components have exponential multistate safety functions with intensities of departure from the safety state subsets estimated by application of the first part of the program.

The computer program may be used for real technical systems i.e. maritime transportation systems [6]. It may also be used to construct the integrated safety and safety decision support systems for various maritime and coastal transport sectors. This program together with the description may also be included into this training course addressed to industry.

Acknowledgements

The paper describes the part of the work in the Poland-Singapore Joint Research Project titled “Safety and Reliability of Complex Industrial Systems and Processes” supported by grants from the Poland’s Ministry of Science and Higher Education (MSHE grant No. 63/N-Singapore/2007/0) and the Agency for Science, Technology and Research of Singapore (A*STAR SERC grant No. 072 1340050).

References

[1] Blokus-Roszkowska A., Guze S., Kołowrocki K., Jurdziński M., Kwiatuszewska-Sarnecka B., Milczek B., Soszyńska J., Salahuddin Habibullah M. & Fu X. (2009). Integrated package of solutions for complex industrial systems and processes safety and reliability optimization. WP 7 – Task 7.3. Methods of unknown parameters of complex technical systems operation, reliability, availability, safety models evaluation. Report. Poland-Singapore Joint Project.

[2] Blokus-Roszkowska, A., Guze, S., Kołowrocki, K., Kwiatuszewska-Sarnecka, B. & Soszyńska, J. (2008). Models of safety, reliability and availability evaluation of complex technical systems related to their operation processes. WP 4 – Task 4.1. Report. Poland-Singapore Joint Project.

[3] Blokus-Roszkowska A., Guze S., Kołowrocki K., Kwiatuszewska-Sarnecka B., Milczek B. & Soszyńska J. (2009). Integrated package of solutions for complex industrial systems and

processes safety and reliability optimization. WP 7 – Task 7.2. Methods of complex technical systems reliability, availability and safety evaluation and prediction. Report. Poland-Singapore Joint Project.

[4] Blokus-Roszkowska, A., Guze, S., Kołowrocki, K. & Soszyńska, J. (2010). Packages of Tools for Complex Industrial Systems and Processes Safety and Reliability Optimization. WP8 - Task 8.4. The computer program for safety models identification of the components of complex technical systems. Report. Poland-Singapore Joint Project.

[5] Kołowrocki K. & Soszyńska J. (2009). Integrated package of solutions for complex industrial systems and processes safety and reliability optimization. WP 7 – Task 7.1. Methods of complex technical systems operation processes modeling. Report. Poland-Singapore Joint Project.

[6] Kołowrocki, K., Soszyńska, J. & Kamiński, P. (2010). Applications and Testing of Packages of Tools in Complex Maritime Transportation Systems and Processes Safety and Reliability Optimization. WP9 – Task 9.4. Stena Baltica ferry technical system operation, safety, risk and cost identification, prediction and optimization. Report. Poland-Singapore Joint Project.