BFO 2020 Spatiotemporal Axioms

If something occupies a temporal region, then it exists at that region [bmc-1]

$\forall$a,t(occupiesTemporalRegion(a,t) $\rightarrow$ existsAt(a,t))

Exists at is a lower bound on first argument [jqz-1]

$\forall$p,q,r(existsAt(p,q)$\wedge$temporalPartOf(p,r) $\rightarrow$ existsAt(r,q))

Occupies temporal region is functional on second argument [wzd-1]

$\forall$p,q,r(occupiesTemporalRegion(p,q)$\wedge$occupiesTemporalRegion(p,r) $\rightarrow$ q=r)

Temporally projects onto is functional on second argument [jtq-1]

$\forall$p,q,r(temporallyProjectsOnto(p,q)$\wedge$temporallyProjectsOnto(p,r) $\rightarrow$ q=r)

Spatially projects onto is functional on second argument [fdb-1]

$\forall$p,q,r,s(spatiallyProjectsOnto(p,q,r)$\wedge$spatiallyProjectsOnto(p,s,r) $\rightarrow$ q=s)

Occupies spatiotemporal region is functional on second argument [uqt-1]

$\forall$p,q,r(occupiesSpatiotemporalRegion(p,q)$\wedge$occupiesSpatiotemporalRegion(p,r) $\rightarrow$ q=r)

Occurs in is a lower bound on second argument [yex-1]

$\forall$p,c1,c2(occursIn(p,c1)$\wedge$($\forall$t(existsAt(p,t) $\leftrightarrow$ locatedIn(c1,c2,t))) $\rightarrow$ occursIn(p,c2))

If a occupies spatial region b then if a is an instance of site then b is an instance of three dimensional spatial region [uqb-1]

$\forall$p,q,t(occupiesSpatialRegion(p,q,t)$\wedge$instanceOf(p,site,t)
$\rightarrow$ instanceOf(q,threeDimensionalSpatialRegion,t))

The temporal region during which a process occurs is the same as that which the spatiotemporal region the process occupies temporally projects onto [cur-1]

$\forall$p,t(occupiesTemporalRegion(p,t)
$\leftrightarrow$ $\exists$st(occupiesSpatiotemporalRegion(p,st)$\wedge$temporallyProjectsOnto(st,t)))

Temporally projects onto has domain spatiotemporal region and range temporal region [cvr-2]

$\forall$a,b(temporallyProjectsOnto(a,b)
$\rightarrow$ $\exists$t instanceOf(a,spatiotemporalRegion,t)$\wedge$instanceOf(b,temporalRegion,b))

If a occupies spatial region b then if a is an instance of material entity then b is an instance of three dimensional spatial region [ocw-1]

$\forall$p,q,t(occupiesSpatialRegion(p,q,t)$\wedge$instanceOf(p,materialEntity,t)
$\rightarrow$ instanceOf(q,threeDimensionalSpatialRegion,t))

A process boundary occupies a spatiotemporal instant [atz-1]

$\forall$pb,tr($\exists$t instanceOf(pb,processBoundary,t)$\wedge$occupiesTemporalRegion(pb,tr)
$\rightarrow$ instanceOf(tr,temporalInstant,tr))

For every process there's a corresponding spatiotemporal region [qyy-1]

$\forall$p($\exists$t(instanceOf(p,process,t)$\vee$instanceOf(p,processBoundary,t))
$\rightarrow$ $\exists$s occupiesSpatiotemporalRegion(p,s))

Spatiotemporal regions always project on to some temporal region [scq-1]

$\forall$st($\exists$t instanceOf(st,spatiotemporalRegion,t)
$\rightarrow$ $\exists$t(instanceOf(t,temporalRegion,t)$\wedge$temporallyProjectsOnto(st,t)))

Every temporal region is a projection from a spatiotemporal region [xco-2]

$\forall$tr(instanceOf(tr,temporalRegion,tr)
$\rightarrow$ $\exists$st($\exists$t instanceOf(st,spatiotemporalRegion,t)$\wedge$temporallyProjectsOnto(st,tr)))

Spatially projects onto is time indexed and has domain: spatiotemporal region and range: spatial region [blj-1]

$\forall$a,b,t(spatiallyProjectsOnto(a,b,t)
$\rightarrow$ instanceOf(a,spatiotemporalRegion,t)$\wedge$instanceOf(b,spatialRegion,t)
$\wedge$instanceOf(t,temporalRegion,t))

Occupies temporal region has domain process or process boundary and range temporal region [lyx-2]

$\forall$a,b (occupiesTemporalRegion(a,b)
$\quad \rightarrow (\exists$t(instanceOf(a,process,t)$\lor$instanceOf(a,processBoundary,t)))
$\quad \land$instanceOf(b,temporalRegion,b))

Spatiotemporal regions always project on to some spatial region at any time [geq-1]

$\forall$st,t (instanceOf(st,spatiotemporalRegion,t)
$\quad \rightarrow \exists$s,tp (temporalPartOf(tp,t)$\land$instanceOf(s,spatialRegion,tp)
$\qquad \land$spatiallyProjectsOnto(st,s,tp)))

Every spatial region is a projection from a spatiotemporal region [mdb-1]

$\forall$sr ($\exists$t instanceOf(sr,spatialRegion,t)
$\quad \rightarrow \exists$st ($\exists$t instanceOf(st,spatiotemporalRegion,t)$\land \exists$t spatiallyProjectsOnto(st,sr,t)))

Occupies spatiotemporal region has domain process or process boundary and range spatiotemporal region [vvo-1]

$\forall$a,b (occupiesSpatiotemporalRegion(a,b)
$\quad \rightarrow (\exists$t(instanceOf(a,process,t)$\lor$instanceOf(a,processBoundary,t)))
$\quad \land \exists$t instanceOf(b,spatiotemporalRegion,t))

A process occupies at least a temporal interval [fzy-1]

$\forall$proc,tr ($\exists$t instanceOf(proc,process,t)$\land$occupiesTemporalRegion(proc,tr)
$\quad \rightarrow \exists$interval (instanceOf(interval,temporalInterval,interval)
$\qquad \land$temporalPartOf(interval,tr)))

If one occurrent is part of another, then the temporal region of the first is part of the temporal region of the second [jiv-1]

$\forall$o1,o2,t1,t2 (($\exists$t(instanceOf(o1,process,t)$\lor$instanceOf(o1,processBoundary,t)))
$\quad \land \exists$t instanceOf(o2,process,t)$\land$occurrentPartOf(o1,o2)
$\quad \land$occupiesTemporalRegion(o1,t1)$\land$occupiesTemporalRegion(o2,t2)
$\quad \rightarrow$temporalPartOf(t1,t2))

If one process or process boundary is part of another, then their corresponding temporal regions are also in a parthood relation [iqe-1]

$\forall$o1,o2,st1,st2 (($\exists$t(instanceOf(o1,process,t)$\lor$instanceOf(o1,processBoundary,t)))
$\quad \land (\exists$t(instanceOf(o2,process,t)$\lor$instanceOf(o2,processBoundary,t)))
$\quad \land$occurrentPartOf(o1,o2)$\land$occupiesSpatiotemporalRegion(o1,st1)
$\quad \land$occupiesSpatiotemporalRegion(o2,st2)
$\quad \rightarrow$occurrentPartOf(st1,st2))

If a process or process boundary is part of another, their spatiotemporal regions are part too [kqv-1]

$\forall$p1,p2 (($\exists$t instanceOf(p1,process,t)$\lor \exists$t instanceOf(p1,processBoundary,t))
$\quad \land (\exists$t instanceOf(p2,process,t)$\lor \exists$t instanceOf(p2,processBoundary,t))
$\quad \rightarrow$(occurrentPartOf(p1,p2)
$\quad \leftrightarrow \exists$st1,st2 (occupiesSpatiotemporalRegion(p1,st1)
$\qquad \land$occupiesSpatiotemporalRegion(p2,st2)
$\qquad \land$occurrentPartOf(st1,st2))))

Process or process boundary p occupies temporal region t iff every part of p temporally occupies a part of t, and there isn't a smaller part of t that p occupies. [tao-1]

$\forall$o,t (($\exists$t1 instanceOf(o,process,t1)$\lor \exists$t1 instanceOf(o,processBoundary,t1))
$\quad \land$instanceOf(t,temporalRegion,t)
$\quad \rightarrow$(occupiesTemporalRegion(o,t)
$\quad \leftrightarrow (\forall$op (occurrentPartOf(op,o)
$\qquad \rightarrow \forall$tp (occupiesTemporalRegion(op,tp) $\rightarrow$occurrentPartOf(tp,t))))
$\quad \land \neg(\exists$t'(t'$\neq$t$\land$occurrentPartOf(t',t)
$\qquad \land$occupiesTemporalRegion(o,t')))))

Process p (or boundary) occupies spatiotemporal region st iff every part of p occupies spatiotemporal region a part of st, and there isn't a smaller part of st that p occupies. [dki-1]

$\forall$o,st (($\exists$t1 instanceOf(o,process,t1)$\lor \exists$t1 instanceOf(o,processBoundary,t1))
$\quad \land \exists$t1 instanceOf(st,spatiotemporalRegion,t1)
$\quad \rightarrow$(occupiesSpatiotemporalRegion(o,st)
$\quad \leftrightarrow (\forall$op (occurrentPartOf(op,o)
$\qquad \rightarrow \forall$stp (occupiesSpatiotemporalRegion(op,stp)
$\qquad \quad \rightarrow$occurrentPartOf(stp,st))))
$\quad \land \neg(\exists$st'(st'$\neq$st$\land$occurrentPartOf(st',st)
$\qquad \land$occupiesSpatiotemporalRegion(o,st')))))