BFO 2020 Spatial Axioms

Occurs in and environs are inverse relations [uys-1]

$\forall$a,b (occursIn(a,b) $\leftrightarrow$ environs(b,a))

Located in and location of are inverse relations [kaw-1]

$\forall$t,a,b (locatedIn(a,b,t) $\leftrightarrow$ locationOf(b,a,t))

Occurs in is dissective on first argumentwhen it is an occurrent [jil-1]

$\forall$p,q,r (occursIn(p,q) $\wedge$ occurrentPartOf(r,p) $\rightarrow$ occursIn(r,q))

If a process (or process boundary) occurs in a continuant, that continuant exists at least as long as the process does [dxv-1]

$\forall$p,c (occursIn(p,c) $\rightarrow$ $\forall$t(existsAt(p,t) $\rightarrow$ existsAt(c,t)))

Located in is dissective on third argument, a temporal region [put-1]

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

Located in is a lower bound on second argument [evu-1]

$\forall$p,q,r,s (locatedIn(p,q,r) $\wedge$ continuantPartOf(q,s,r) $\rightarrow$ locatedIn(p,s,r))

Located in is dissective on first argumentwhen it is a continuant [wty-1]

$\forall$p,q,r,s (locatedIn(p,q,r) $\wedge$ continuantPartOf(s,p,r) $\rightarrow$ locatedIn(s,q,r))

Occupies spatial region is functional on second argument [zls-1]

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

Occupies spatial region is dissective on third argument, a temporal region [mud-1]

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

Spatially projects onto is dissective on third argument, a temporal region [ivt-1]

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

Located in is transitive at a time [xlm-1]

$\forall$a,b,c,t,t2 (locatedIn(a,b,t) $\wedge$ locatedIn(b,c,t2) $\wedge$ temporalPartOf(t,t2)
$\rightarrow$ locatedIn(a,c,t))

If a location of b then if a is an instance of continuant fiat boundary then b is an instance of continuant fiat boundary [wte-1]

$\forall$p,q,t (locationOf(p,q,t) $\wedge$ instanceOf(p,continuantFiatBoundary,t)
$\rightarrow$ instanceOf(q,continuantFiatBoundary,t))

All spatial regions are part of a 3 dimensional spatial region [xcx-1]

$\forall$s,t (instanceOf(s,spatialRegion,t)
$\rightarrow$ $\exists$s3 (instanceOf(s3,threeDimensionalSpatialRegion,t) $\wedge$ continuantPartOf(s,s3,t)))

Occurs in is lower bound location [czc-1]

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

If something is located in something else then the region of the first is part of the region of the second [uas-1]

$\forall$a,b,t (locatedIn(a,b,t)
$\rightarrow$ $\exists$r1,r2,t2 (temporalPartOf(t2,t) $\wedge$ occupiesSpatialRegion(a,r1,t2)
$\wedge$ occupiesSpatialRegion(b,r2,t2) $\wedge$ continuantPartOf(r1,r2,t2)))

Occurs in has domain process or process boundary and range material entity or site [tfw-1]

$\forall$a,b (occursIn(a,b)
$\rightarrow$ ($\exists$t(instanceOf(a,process,t) $\vee$ instanceOf(a,processBoundary,t)))
$\wedge$ ($\exists$t(instanceOf(b,materialEntity,t) $\vee$ instanceOf(b,site,t))))

Spatial regions don't change what they are part of. [mlb-1]

$\forall s,sp\,(\exists t\,(instanceOf(s,spatialRegion,t) \land continuantPartOf(sp,s,t))$
$\quad \rightarrow \forall t\,(\exists sPrime\ continuantPartOf(sPrime,s,t) \rightarrow continuantPartOf(sp,s,t)))$

Occupies spatial region is time indexed and has domain: independent continuant but not spatial region and range: spatial region [lzw-1]

$\forall a,b,t\,(occupiesSpatialRegion(a,b,t)$
$\quad \rightarrow instanceOf(a,independentContinuant,t) \land \neg instanceOf(a,spatialRegion,t)$
$\quad \land instanceOf(b,spatialRegion,t) \land instanceOf(t,temporalRegion,t))$

If there are two independent continuants that are not spatial regions, and one is part of the other, then it is located in the other [bao-1]

$\forall a,b,t\,(continuantPartOf(a,b,t) \land instanceOf(a,independentContinuant,t)$
$\quad \land \neg instanceOf(a,spatialRegion,t) \land instanceOf(b,independentContinuant,t)$
$\quad \land \neg instanceOf(b,spatialRegion,t)$
$\quad \rightarrow locatedIn(a,b,t))$

Spatial region is the union of zero dimensional spatial region, one dimensional spatial region, two dimensional spatial region, and three dimensional spatial region [wnm-1]

$\forall i,t\,(instanceOf(i,spatialRegion,t)$
$\quad \rightarrow instanceOf(i,zeroDimensionalSpatialRegion,t)$
$\quad \lor instanceOf(i,oneDimensionalSpatialRegion,t)$
$\quad \lor instanceOf(i,twoDimensionalSpatialRegion,t)$
$\quad \lor instanceOf(i,threeDimensionalSpatialRegion,t))$

No two material entities occupy the same space unless they coincide [scr-1]

$\forall m1,m2,s,t\,(instanceOf(m1,materialEntity,t) \land occupiesSpatialRegion(m1,s,t)$
$\quad \land instanceOf(m2,materialEntity,t) \land occupiesSpatialRegion(m2,s,t)$
$\quad \rightarrow (continuantPartOf(m2,m1,t) \land continuantPartOf(m1,m2,t)) \lor m1{=}m2)$

Located in is time indexed and has domain: independent continuant but not spatial region and range: independent continuant but not spatial region [bge-1]

$\forall a,b,t\,(locatedIn(a,b,t)$
$\quad \rightarrow instanceOf(a,independentContinuant,t) \land \neg instanceOf(a,spatialRegion,t)$
$\quad \land instanceOf(b,independentContinuant,t) \land \neg instanceOf(b,spatialRegion,t)$
$\quad \land instanceOf(t,temporalRegion,t))$

At all times t, there's a part of t when c occupies spatial region r iff every part of c occupies a part of r, and there isn't a smaller part of r that c occupies. [grv-1]

$\forall c,r,t\,(instanceOf(c,independentContinuant,t) \land \neg instanceOf(c,spatialRegion,t)$
$\quad \land instanceOf(r,spatialRegion,t)$
$\quad \rightarrow \exists t2\,(temporalPartOf(t2,t)$
$\quad \quad \land (occupiesSpatialRegion(c,r,t2)$
$\quad \quad \quad \leftrightarrow (\forall cp\,(continuantPartOf(cp,c,t2)$
$\quad \quad \quad \quad \rightarrow \forall rp\,(occupiesSpatialRegion(cp,rp,t2)$
$\quad \quad \quad \quad \quad \rightarrow continuantPartOf(rp,r,t2))))$
$\quad \quad \quad \land \neg(\exists r'(r' {\neq} r \land continuantPartOf(r',r,t2)$
$\quad \quad \quad \quad \land occupiesSpatialRegion(c,r',t2))))))$