BFO 2020 Spatiotemporal Axioms

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

$$\forall a,t\,(\text{occupiesTemporalRegion}(a,t) \rightarrow \text{existsAt}(a,t))$$

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

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

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

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

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

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

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

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

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

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

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

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

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]

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

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]

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

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

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

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

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

Temporally projects onto has domain spatiotemporal region and range temporal region [cvr-1]

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

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

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

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

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

Every temporal region is a projection from a spatiotemporal region [xco-1]

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

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

$$\forall st,t\,(\text{instanceOf}(st,\text{spatiotemporalRegion},t) \rightarrow \exists s,tp\,(\text{temporalPartOf}(tp,t) \wedge \text{instanceOf}(s,\text{spatialRegion},tp) \wedge \text{spatiallyProjectsOnto}(st,s,tp)))$$

Occupies temporal region has domain process or process boundary and range temporal region [lyx-1]

$$\forall a,b\ (\text{occupiesTemporalRegion}(a,b) \rightarrow (\exists t\,(\text{instanceOf}(a,\text{process},t) \vee \text{instanceOf}(a,\text{processBoundary},t))) \wedge \exists t\,\text{instanceOf}(b,\text{temporalRegion},t))$$

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

$$\forall sr\ (\exists t\,\text{instanceOf}(sr,\text{spatialRegion},t) \rightarrow \exists st\,(\exists t\,\text{instanceOf}(st,\text{spatiotemporalRegion},t) \wedge \exists t\,\text{spatiallyProjectsOnto}(st,sr,t)))$$

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

$$\forall a,b\ (\text{occupiesSpatiotemporalRegion}(a,b) \rightarrow (\exists t\,(\text{instanceOf}(a,\text{process},t) \vee \text{instanceOf}(a,\text{processBoundary},t))) \wedge \exists t\,\text{instanceOf}(b,\text{spatiotemporalRegion},t))$$

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

$$\forall \text{proc},tr\ (\exists t\,\text{instanceOf}(\text{proc},\text{process},t) \wedge \text{occupiesTemporalRegion}(\text{proc},tr) \rightarrow \exists \text{interval}\,(\text{instanceOf}(\text{interval},\text{temporalInterval},\text{interval}) \wedge \text{temporalPartOf}(\text{interval},tr)))$$

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]

$$\forall o1,o2,t1,t2\ ((\exists t\,(\text{instanceOf}(o1,\text{process},t) \vee \text{instanceOf}(o1,\text{processBoundary},t))) \wedge \exists t\,\text{instanceOf}(o2,\text{process},t) \wedge \text{occurrentPartOf}(o1,o2) \wedge \text{occupiesTemporalRegion}(o1,t1) \wedge \text{occupiesTemporalRegion}(o2,t2) \rightarrow \text{temporalPartOf}(t1,t2))$$

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

$$\forall o1,o2,st1,st2\ ((\exists t\,(\text{instanceOf}(o1,\text{process},t) \vee \text{instanceOf}(o1,\text{processBoundary},t))) \wedge (\exists t\,(\text{instanceOf}(o2,\text{process},t) \vee \text{instanceOf}(o2,\text{processBoundary},t))) \wedge \text{occurrentPartOf}(o1,o2) \wedge \text{occupiesSpatiotemporalRegion}(o1,st1) \wedge \text{occupiesSpatiotemporalRegion}(o2,st2) \rightarrow \text{occurrentPartOf}(st1,st2))$$

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

$$\forall p1,p2\ ((\exists t\,\text{instanceOf}(p1,\text{process},t) \vee \exists t\,\text{instanceOf}(p1,\text{processBoundary},t)) \wedge (\exists t\,\text{instanceOf}(p2,\text{process},t) \vee \exists t\,\text{instanceOf}(p2,\text{processBoundary},t)) \rightarrow (\text{occurrentPartOf}(p1,p2) \leftrightarrow \exists st1,st2\,(\text{occupiesSpatiotemporalRegion}(p1,st1) \wedge \text{occupiesSpatiotemporalRegion}(p2,st2) \wedge \text{occurrentPartOf}(st1,st2))))$$

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]

$$\forall o,t\ ((\exists t1\,\text{instanceOf}(o,\text{process},t1) \vee \exists t1\,\text{instanceOf}(o,\text{processBoundary},t1)) \wedge \text{instanceOf}(t,\text{temporalRegion},t) \rightarrow (\text{occupiesTemporalRegion}(o,t) \leftrightarrow (\forall op\,(\text{occurrentPartOf}(op,o) \rightarrow \forall tp\,(\text{occupiesTemporalRegion}(op,tp) \rightarrow \text{occurrentPartOf}(tp,t)))) \wedge \neg(\exists t'(t' \neq t \wedge \text{occurrentPartOf}(t',t) \wedge \text{occupiesTemporalRegion}(o,t')))))$$

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]

$$\forall o,st\ ((\exists t1\,\text{instanceOf}(o,\text{process},t1) \vee \exists t1\,\text{instanceOf}(o,\text{processBoundary},t1)) \wedge \exists t1\,\text{instanceOf}(st,\text{spatiotemporalRegion},t1) \rightarrow (\text{occupiesSpatiotemporalRegion}(o,st) \leftrightarrow (\forall op\,(\text{occurrentPartOf}(op,o) \rightarrow \forall stp\,(\text{occupiesSpatiotemporalRegion}(op,stp) \rightarrow \text{occurrentPartOf}(stp,st)))) \wedge \neg(\exists st'(st' \neq st \wedge \text{occurrentPartOf}(st',st) \wedge \text{occupiesSpatiotemporalRegion}(o,st')))))$$

Alan Ruttenberg, November 12, 2021. The most recent version of this file will always be in the GitHub repository https://github.com/bfo-ontology/bfo-2020