

United States Court of Appeals for the Federal Circuit

2009-1307

ROLLS-ROYCE, PLC,

Plaintiff-Appellee,

v.

UNITED TECHNOLOGIES CORPORATION,

Defendant-Appellant.

William P. Berridge, Oliff & Berridge, PLC, of Alexandria, Virginia, argued for plaintiff-appellee. With him on the brief were Richard E. Rice, James A. Oliff, and Peter T. Ewald. Of counsel on the brief were Gerald Sobel and Richard G. Greco, Kaye Scholer, LLP, of New York, New York.

Mark L. Levine, Bartlit Beck Herman Palenchar & Scott LLP, of Chicago, Illinois, argued for defendant-appellant. With him on the brief was Michael J. Valaik.

Appealed from: United States District Court for the Eastern District of Virginia

Judge Leonie M. Brinkema

United States Court of Appeals for the Federal Circuit

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ROLLS-ROYCE, PLC,

Plaintiff-Appellee,

v.

UNITED TECHNOLOGIES CORPORATION,

Defendant-Appellant.

Appeal from the United States District Court for the Eastern District of Virginia in case no. 1:05-CV-362, Judge Leonie M. Brinkema.

DECIDED: May 5, 2010

Before MICHEL, Chief Judge, RADER, and SCHALL, Circuit Judges.

RADER, Circuit Judge.

In an appeal under 35 U.S.C. § 146 from a patent interference proceeding, the United States District Court for the Eastern District of Virginia held the claims of U.S. Patent No. 6,071,077 (the “077 patent”) patentable over Reissue Application No. 09/874,931 (the “931 application”). See *Rolls-Royce, PLC v. United Techs. Corp.*, No. 05-362 (E.D. Va. Mar. 31, 2009). Because the district court correctly determined that Rolls-Royce, PLC’s (“Rolls-Royce”) ’077 patent would not have been obvious in light of United Technologies Corp.’s (“UTC”) ’931 application, this court affirms.

I.

The technology in Rolls-Royce's '077 patent and UTC's '931 application relates to swept fan blades used on turbofan jet engines. The fan generally consists of a cascade of fan blades that are attached to, and extend radially outward from, a central rotatable hub. The fan blades rotate around the hub to provide propulsive thrust to air entering the engine by increasing the pressure and momentum of that air. A cylindrical-shaped cover, known as a casing, encloses the fan and the rest of the engine.

Shockwaves contribute to engine noise and cause inefficiencies. This technology addresses two types of shock: endwall shock and passage shock. Endwall shock arises when pressure waves reflect off the engine casing and into the air flow. Passage shock arises from the supersonic flow of air over the fan blades. UTC's '931 application notes that the leading edge of the fan blade creates passage shock upon initial contact with the air flow. Endwall shock and passage shock bear no relation to each other and, in fact, arise in different places within the fan.

To reduce shockwaves, the prior art teaches to sweep blades either rearward or forward. A blade bent toward the relative velocity vector is swept forward; a blade bent away from the relative velocity vector is swept rearward. The relative velocity vector is the magnitude and direction of the air flow that hits the leading edge of a fan blade. The relative velocity vector is a combination of axial and circumferential air flow. The axial air flow is the flow of air toward the engine as it engages air along its path during flight. The circumferential air flow is the flow of air in the direction of the rotation of the blades caused by the blades themselves.

The sweep angle measures the degree of sweep in a blade. Again, these angles may incline forward or rearward. In a forward sweep angle, the blade bends toward the relative velocity vector. In a rearward sweep angle, the blade bends away from the relative velocity vector. The sweep angle at any point on a fan blade leading edge is a function of the relative velocity vector and the leading edge shape at that point.

II.

UTC is the assignee of U.S. Patent No. 5,642,985 (the “985 patent”). It was filed on November 17, 1995 as U.S. Patent Application No. 08/559,965 (the “965 application”). After the ’985 patent issued, UTC filed two successive reissue applications based on the ’985 patent. The first, Reissue Application No. 09/343,736 was filed on June 30, 1999 and issued on March 18, 2003 as U.S. Patent No. RE38,040 (the “040 patent”). The second, UTC’s ’931 application, was filed on June 5, 2001. Thus, UTC’s earliest disclosure dates back to 1995.

Rolls-Royce filed British Patent Application No. 9607316.8 on April 9, 1996. On March 18, 1997, Rolls-Royce filed a parallel U.S. Patent Application No. 08/819,269 (the “269 application”). During the pendency of the ’269 application, Rolls-Royce filed Continuation-in-Part Application No. 09/168,968 (the “968 application”) on October 9, 1998. The ’968 application issued on June 6, 2000 as Rolls-Royce’s ’077 patent. Rolls-Royce’s earliest disclosure dates back to 1996.

On December 31, 2003, the Board of Patent Appeals and Interferences (“the Board”) declared Patent Interference No. 105,195 (“the ’195 interference”) between Rolls-Royce’s ’077 patent and UTC’s ’931 application. With an effective filing date of November 17, 1995 for its ’931 application, UTC was named the senior party, and Rolls-

Royce, with an effective date of April 9, 1996 for its '077 patent, was named the junior party. The Board defined a single count in the interference corresponding to Claim 23 of UTC's application as follows:

A fan stage of a ducted fan gas turbine engine that is rotatable about an axis of rotation and defines a downstream direction along the axis of rotation, comprising:

[a] a fan casing that defines an inner duct wall having a fan rotor region;

[b] a hub disposed concentrically relative to the fan casing;

[c] a fan rotor that includes multiple swept fan blades, the swept fan blades being spaced apart around the hub and being capable of rotating at speeds providing supersonic working medium gas velocities over the blades to cause a shock in the gas adjacent the inner duct wall, each of the multiple swept fan blades having:

[d] a tip profile that corresponds to the inner duct wall of the fan casing;

[e] a leading edge that defines a variable sweep angle in a direction perpendicular to the axis of rotation, the leading edge including:

[i] an inner region adjacent the hub, the inner region defining a forward sweep angle;

[ii] an intermediate region between the inner region and the fan casing, the intermediate region defining a rearward sweep angle; and

[iii] an outer region between the intermediate region and the fan casing, the outer region being translated forward relative to a leading edge with the same sweep angle as an outward boundary of the intermediate region to provide a sweep angle that causes the blade to intercept the shock.

'931 application claim 23 (emphasis added). Each fan blade has three regions—an inner, an intermediate, and an outer region. The area closest to the axis of rotation at the hub is the inner region. The area farthest from the center of the engine and closest to the casing surrounding the engine is the outer region. The intermediate region falls in

between. The count defines a fan blade with a swept-forward inner region, a swept-rearward intermediate region, and forward-leaning outer region.

With the outer region translated forward, the blade intercepts the endwall shock. '931 application col.4 ll.1–6. Because the leading edge of the blade creates the passage shock, the blade configuration that intercepts the endwall shock also creates a coincidence between the endwall shock and the passage shock. '931 application col.4 ll.57–62. According to the '931 application, this coincidence decreases the aerodynamic penalty of the two separate shocks. '931 application col.3 ll.63–67.

Claim 8 of Rolls-Royce's '077 patent, also corresponding to the count, reads as follows:

A fan stage of a ducted fan gas turbine engine that is at least in part rotatable about an axis of rotation and defines a downstream direction along the axis of rotation, comprising:

[a] a fan casing that defines an inner duct wall having a fan rotor region, the inner duct wall of the fan casing at the fan rotor region being convergent;

[b] a hub disposed concentrically relative to the fan casing;

[c] a fan rotor that includes multiple swept fan blades, the swept fan blades being spaced apart around the hub, each of the multiple swept fan blades having:

[d] a tip profile that is convergent so as to substantially correspond to the convergent inner duct wall of the fan casing;

[e] a leading edge that defines a variable sweep angle in a direction perpendicular to the axis of rotation, the leading edge including:

[i] an inner region adjacent the hub, the inner region defining a forward sweep angle;

[ii] an intermediate region between the inner region and the fan casing, the intermediate region defining a rearward sweep angle;
and

[iii] an outer region between the intermediate region and the fan casing, the outer region defining a forward sweep angle.

'077 patent col.8 l.58–col.9 l.14(emphasis added).

On April 8, 2004, Rolls-Royce filed a preliminary motion for judgment based on no interference-in-fact under 37 C.F.R. § 1.633(b). On February 2, 2005, the Board denied Rolls-Royce's preliminary motion and entered a final judgment for UTC.

“Translated forward” and “a sweep angle that causes the blade to intercept the shock” are the only contested terms in this case. The Board construed “translated forward” in UTC's '931 application to mean “that the leading edge of the fan blade is moved forward, towards the airflow direction.” The airflow direction is also the direction of the relative velocity vector. The Board stated that “a sweep angle that causes the blade to intercept the shock” in UTC's '931 application “is broad enough to cover fan blades with an outer region that has a rearward sweep angle or a forward sweep angle.” In other words, the Board interpreted the claim to embrace both a forward and rearward sweep angle. Rolls-Royce did not contest priority of invention, i.e., it did not allege an earlier date of invention. Accordingly, the Board's decision that Rolls-Royce had “failed to sufficiently demonstrate by a preponderance of the evidence that no [Rolls-Royce] claim interferes with a [UTC] claim” resulted in the Board entering judgment against Rolls-Royce.

Rolls-Royce appealed the Board's decision to the U.S. District Court for the Eastern District of Virginia under 35 U.S.C. § 146. The district court conducted a three-day bench trial to receive testimonial and documentary evidence. On April 1, 2009, the district court reversed the Board's decision and entered judgment on the '195 interference in favor of Rolls-Royce.

The district court construed “the outer region being translated forward relative to a leading edge with the same sweep angle as an outward boundary of the intermediate region to provide a sweep angle that causes the blade to intercept the shock” of claim 23 to mean “an outer region, which is moved axially forward, and has a rearward sweep angle that is either constant or decreasing to a minimum of zero degree sweep.” Thus, according to the district court, “translated forward” meant only moved forward toward the axial direction. The district court also concluded that “a sweep angle that causes the blade to intercept the shock” did not include fan blades with a forward sweep angle in the outer region. The district court found that “the shock” in claim 23 meant endwall shock. The district court also found that no prior art taught forward sweep in an outer region. Essentially, the district court construed claim 23 in a manner that did not capture Rolls-Royce’s forward sweep in the outer region of its claim 8. The district court then held that claim 8 was nonobvious in view of UTC’s claim 23 as construed. As such, the court held that the inventions were patentably distinct and there was no interference-in-fact, resulting in a final judgment in favor of Rolls-Royce.

UTC appeals the district court’s claim construction and finding of no interference-in-fact based on obviousness. UTC and Rolls-Royce have stipulated that obviousness, not anticipation, is responsible for the interference-in-fact. This court has jurisdiction under 28 U.S.C. § 1295(a)(1) and 28 U.S.C. § 1295(a)(4)(C).

III.

In an appeal of a 35 U.S.C. § 146 action, this court “review[s] the district court’s factual findings for clear error and its conclusions of law de novo” Winner Int’l Royalty Corp. v. Wang, 202 F.3d 1340, 1344–45 (Fed. Cir. 2000). The purpose of a

patent interference proceeding is to determine whether two parties claim the same patentable invention, and if so, who under the law is entitled to priority of invention. See Noelle v. Lederman, 355 F.3d 1343, 1350 (Fed. Cir. 2004). An interference-in-fact “exists if the subject matter of a claim of one party would, if prior art, have anticipated or rendered obvious the subject matter of a claim of the opposing party and vice versa.” 37 C.F.R. § 41.203(a); see Medichem, S.A. v. Rolabo, S.L., 437 F.3d 1157, 1161 (Fed. Cir. 2006).

This court gives pending claims in interference proceedings their broadest reasonable construction in light of the specification. See Genentech, Inc. v. Chiron Corp., 112 F.3d 495, 499 (Fed. Cir. 1997); 37 C.F.R. § 41.200(b). This court will uphold any reasonable interpretation of disputed claim language by the PTO. See In re Morris, 127 F.3d 1048, 1055 (Fed. Cir. 1997).

The portion of claim 23 of the '931 application at issue is:

the outer region being translated forward relative to a leading edge with the same sweep angle as an outward boundary of the intermediate region to provide a sweep angle that causes the blade to intercept the shock.

'931 application claim 23 (emphases added). The claim terms requiring construction are “translated forward” and “a sweep angle that causes the blade to intercept the shock.”

A.

The district court construed “translated forward” to mean “moved axially forward in the direction of the working medium.” The district court found that one of ordinary skill in the art would have several years of experience designing fan blades with, most

likely, an advanced engineering degree in fluid mechanics. The parties do not contest the district court's finding regarding the level of ordinary skill in the art.

The plain language of "translated forward" means moved toward the forward direction, but the claim language does not designate a clear "forward" direction. The district court found that one of ordinary skill in the art would necessarily have consulted the specification to learn the meaning of "translated forward." The district court also found no use of the term "translation" in the industry or in any prior art other than the related '985 patent.

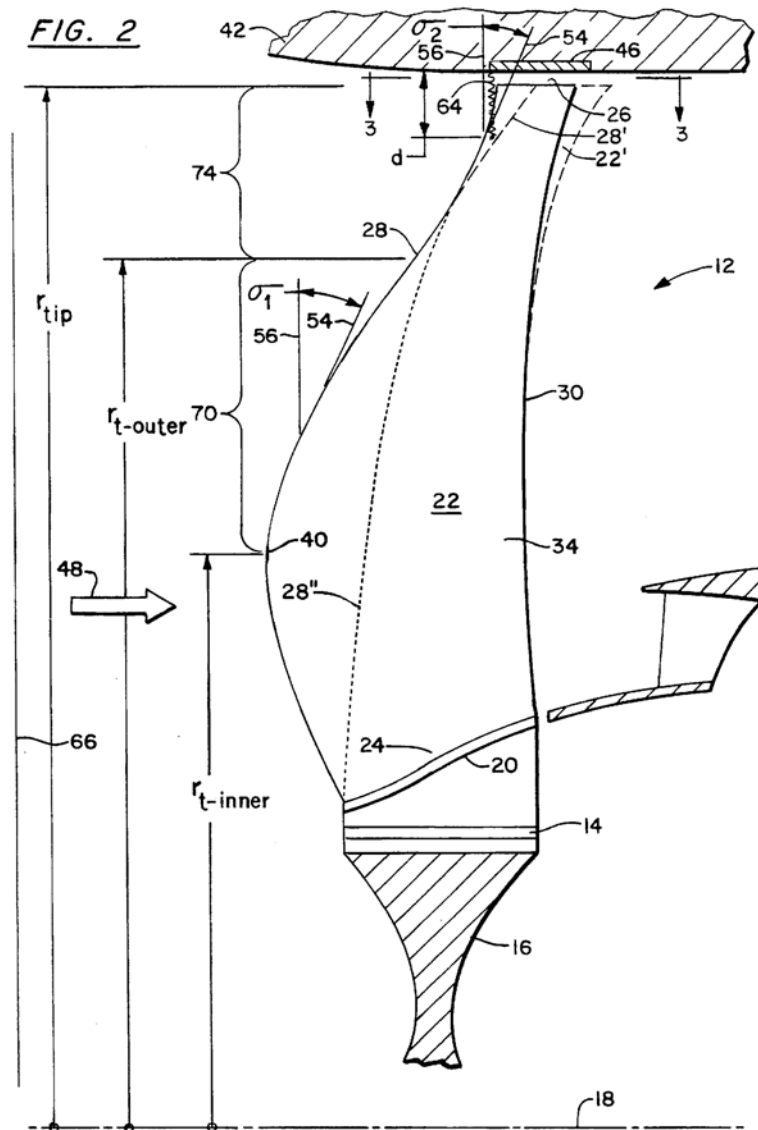
As the claim language does not clearly state the directional tilt of the outer region, this court as well consults the specification. Based on that source, this court construes "translated forward" to mean "moved forward toward the axial direction." The specification discusses translation forward only with reference to the axial direction, which is parallel to the rotational axis of the fan and engine. The specification, referring to Figure 3, states:

The beneficial effect of the invention is appreciated primarily by reference to FIG. 3 [T]he nonincreasing character of the second sweep angle . . . according to the invention causes a portion of the airfoil leading edge to be far enough forward (upstream) in the working medium flow In addition, the passage shock 66 (which remains attached to the airfoil leading edge and therefore is translated forward along with the leading edge) is brought into coincidence with the endwall shock

The embodiment of FIGS. 2 and 3 illustrates a blade whose leading edge, in comparison to the leading edge of a conventional blade, has been translated axially forward parallel to the rotational axis

'931 application col.4 ll.33–66 (emphases added). As "forward," according to its plain language, must denote a specific direction, this court honors the applicant's choice to define that term with reference to the axial direction.

Figures 2 and 3 of the '931 application illustrate the support for this construction. Figure 2 is a cross sectional view of a swept back fan blade including an alternative leading edge profile shown by dotted lines and a prior art blade shown in phantom.



In Figure 2, the blade formed by solid lines (22) represents an embodiment of the invention. The blade with the dashed lines (22') within $r_{t\text{-outer}}$ to $r_{t\text{tip}}$ represents a prior art blade. The alternative blade formed with dotted lines within $r_{t\text{-inner}}$ and $r_{t\text{-outer}}$ shows a different leading edge profile. The arrows (48), pointed in the direction of the airflow into the engine, indicate a direction opposite the forward axial direction. Translation forward

in the axial direction requires moving the leading edge of the blade directly to the left. In Figure 2, the blade with the dashed lines (22') is moved to the left in the region between $r_{t\text{-outer}}$ to $r_{t\text{tip}}$ to form the blade of the invention shown as a solid line (22). Thus, the blade of the invention (22), from $r_{t\text{-outer}}$ to $r_{t\text{tip}}$, is translated forward (in the axial direction) in comparison with the the prior art blade (22').

Figure 3 is a developed view taken along the line 3—3 of Figure 2 illustrating the tips of four blades along with four prior art blades shown in phantom.

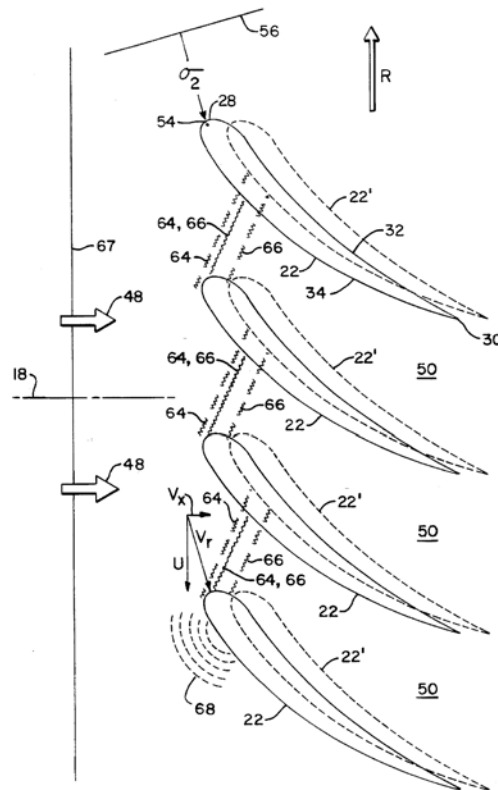


FIG. 3

In Figure 3, the blade formed by solid lines (22) represents an embodiment of the invention. The blade with the dashed lines (22') represents a prior art blade. The arrows (48) point in the direction of the airflow into the engine and also point away from the forward axial direction. Translation forward in the axial direction requires moving the leading edge of the blade directly to the left. In Figure 3, the blade with the dashed lines

(22') is moved to the left to form the blade of the invention shown as a solid line (22). Thus, the invention translates or moves the blade (22) forward in the axial direction from the prior art blade (22').

UTC argues that “translated forward” in the '931 application means “moved forward toward the direction of the relative velocity vector.” UTC contends that movement in any direction—axial or circumferential—is movement toward the relative velocity vector. Under UTC’s proposed construction, either purely circumferential or purely axial movements are encompassed by the term “translated forward.” The axial and circumferential directions are at ninety degree angles to each other. Thus, this court perceives that a construction of “translated forward” that includes both the circumferential and axial directions, at right angles to each other, would unreasonably broaden this claim limitation.

Figure 5 of the '931 application shows movement of the outer region in the circumferential direction.

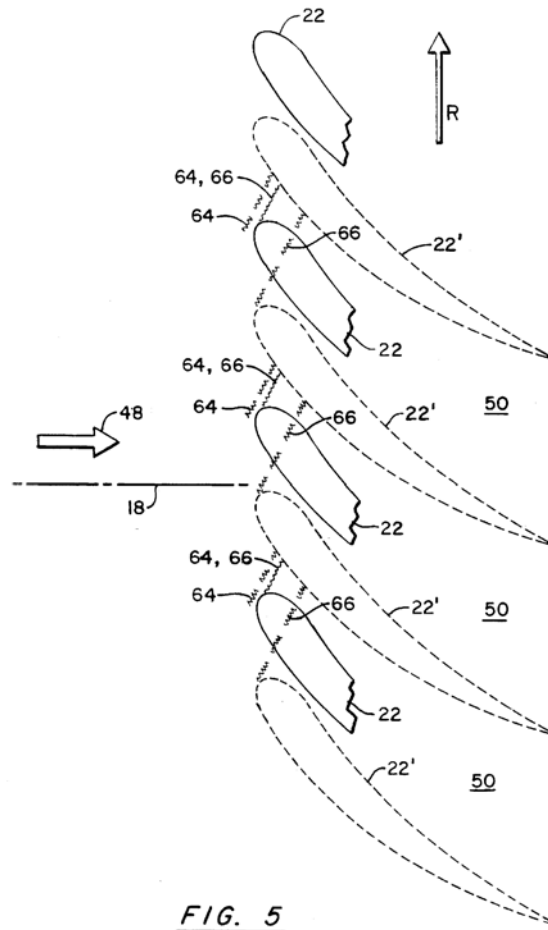


FIG. 5

In Figure 5, the blade formed by solid lines (22) represents an embodiment of the '931 application. The blade with the dashed lines (22') represents a prior art blade. The arrow (R) is pointed in the circumferential direction. Translation forward in the axial direction would require the prior art blade (22') be moved to the left to form the blade (22). As shown by Figure 5, the prior art blade (22') is moved up, not to the left, to form the blade (22). Thus, under this court's claim construction, the blade (22) in Figure 5 is not translated forward in the axial direction.

Although Figure 5 of the '931 application shows movement of the outer region in the circumferential direction, the specification does not support UTC's proposed construction. The specification does not use "translated forward" to describe the

embodiment in Figure 5. Instead, the specification describes the movement in Figure 5 as “displaced circumferentially.” ’931 application col.5 ll.4–12. This court’s construction of “translated forward” (“moved forward toward the axial direction”) excludes the embodiment in Figure 5. Although reluctant to exclude an embodiment, this court must not allow the disclosed embodiment to “outweigh the language of the claim, especially when the court’s construction is supported by the intrinsic evidence.” See TIP Sys., LLC v. Phillips & Brooks/Gladwin, Inc., 529 F.3d 1364, 1373 (Fed. Cir. 2008). In this case, this court cannot allow the claim to encompass both the embodiment in Figures 1 through 3 (with movement toward the axial direction) and the embodiment in Figure 5 (with movement toward the circumferential direction). A claim construction that embraced both alternative embodiments would be unreasonable because the single claimed direction “forward” would then encompass two directions at right angles to each other.

UTC argues that the specification of the ’931 application supports its construction because it states that “the invention contemplates any blade whose airfoil intercepts the endwall shock to bring the passage shock into coincidence with the endwall shock.” ’931 application col.5 ll.2–4. This argument overlooks the language of the claim that specifies the translational direction for the blade. According to the claim, the blade must be “translated forward.” ’931 application claim 23. This court considers unreasonable an interpretation that allows that term to cover two directions at right angles to each other. Thus, interpreting the claim to encompass translation in any direction that causes the airfoil of the fan blade to intercept the endwall shock would unreasonably broaden “translated forward.” Moreover, this court notes that the claim reference to intercepting

the endwall shock appears after the claim specifies forward translation. In that context, the intercepting reference merely describes a benefit derived from forward translation, rather than changing the meaning of “forward” to embrace more than a single direction.

UTC argues that the prosecution history of the related '040 patent shows that “translated forward” means “moved forward toward the direction of the relative velocity vector.” The portion of the prosecution history of the '040 patent serving as a basis for UTC’s argument states:

The applicants’ specification uses the term “translated” in the exact same context in which the claims use it to recite a blade feature in accordance with this aspect of the invention. See, for example, page 4, line 65, and Figures 2 and 5 of the present application.

J.A. 7251. This inference from the prosecution history does not persuade this court because the specification of the '931 application clearly excludes this construction. Moreover, the prosecution history of the '040 patent does not favor one construction over the other. This argument to the examiner of the related '040 patent only describes the use of “translated,” not “translated forward.” The important issue in this claim construction is the direction of the translation, not the mere fact of some translation. Explaining the term “translated” in isolation does not guide this court’s construction of “translated forward.” Also, this prosecution history passage is unclear. A suggestion that the specification uses a term “in the exact same context” as the claims is vague. Indeed that explanation does not assist this court in determining the direction of “forward.” In sum, this court declines to unreasonably broaden a specific claim term based on questionable prosecution history when the specification requires a particular construction.

B.

The district court construed “a sweep angle that causes the blade to intercept the shock” to mean “a sweep angle in the outer region that is constant or decreasing.” It further explained that this construction does not include forward sweep. The plain language of “a sweep angle that causes the blade to intercept the shock” leaves the properties of that claimed angle unclear. The district court found that one of ordinary skill in the art would have necessarily resorted to the specification to interpret “a sweep angle that causes the blade to intercept the shock.”

This court construes “a sweep angle that causes the blade to intercept the shock” to mean “a rearward sweep angle in the outer region that is constant or decreasing” because the specification supports only rearward sweep. The specification states that the sweep angle is “nonincreasing (decreases, or at least does not increase) with increasing radius.” ’931 application col.4 ll.27–29. The invention emphasizes the critical character of the nonincreasing sweep angle in the tip region. ’931 application col.4 ll.46–62. The parties agree that the sweep angle at the boundary between the intermediate and outer regions is a rearward sweep angle. If the outer region translates forward from rearward sweep to zero degree sweep, the sweep angle necessarily decreases. If, however, the outer region translates farther, from zero degree sweep to forward sweep, the sweep angle necessarily increases. For example, translating forward from twenty degrees rearward sweep to five degrees forward sweep would decrease sweep from twenty degrees rearward sweep to zero degrees sweep, then increase sweep from zero degree sweep to five degrees forward sweep. Because the invention of the ’931 application specifies a nonincreasing sweep angle with increasing

radius, this example shows that the invention did not contemplate forward sweep in the outer region.

UTC argues that five degrees forward sweep is actually negative five degrees rearward sweep, but the specification does not use negative signs to indicate forward sweep. For example, the specification describes translating the sweep angle from forward sweep to zero sweep as “nonincreasing (decreases, or at least does not increase).” ’931 application col.5 ll.36–45. If, as UTC suggests, a negative sign could indicate forward sweep, then translating the outer region from forward sweep to zero sweep would be increasing—a direct contradiction of the requirements of the specification.

This court construes “a sweep angle that causes the blade to intercept the shock” from the point of view of a person of ordinary skill in the art. See Phillips v. AWH Corp., 415 F.3d 1303, 1313 (Fed. Cir. 2005) (“It is the person of ordinary skill in the field of the invention through whose eyes the claims are construed.”). The record shows that a person of ordinary skill in the art would consider translating beyond a zero degrees sweep angle to create a forward sweep angle as a total reversal of direction, rather than a mere “decrease” of the angle. This interpretation would remain correct even if negative signs indicated a forward sweep. Also, the record shows that translating the outer region forward toward the axial direction, as required by this court’s construction of “translated forward,” results in a completely unrealistic blade shape well before the sweep angle is reversed to a forward sweep angle. Therefore, a person of ordinary skill in the art would not understand claim 23 of the ’931 application to cover forward sweep.

UTC argues that the specification of the '931 application supports its construction of “a sweep angle that causes the blade to intercept the shock” because it states that “the invention contemplates any blade whose airfoil intercepts the endwall shock to bring the passage shock into coincidence with the endwall shock.” '931 application col.5 ll.2–4. To the contrary, the specification teaches that the sweep angle must be nonincreasing with increasing radius—a reading that cannot include forward sweep. See '931 application col.4 ll.27–29. The district court found that a person of ordinary skill would not have understood the specification to disclose a total reversal of direction from rearward to forward sweep. Interpreting the claim to encompass forward sweep would unreasonably broaden “a sweep angle that causes the blade to intercept the shock.”

UTC argues that the prosecution history of the related '040 patent shows that “a sweep angle that causes the blade to intercept the shock” covers forward sweep in the outer region. The portions of the prosecution history of the '040 patent serving as a basis for UTC’s argument state:

[A] preferred embodiment of the present invention’s blade has a leading edge sweep angle that decreases in a tip region, or put another way, has a leading edge with a tip region that is translated in a direction opposite to that of the sweep of the leading edge intermediate region.

. . . .

[N]one of the prior art . . . discloses or suggests a supersonic turbomachinery blade with a leading edge that is swept in one direction (rearward or forward) and a tip region that is translated in the other direction from its boundary with the intermediate region.

J.A. 7171–76. Again, this court does not read this prosecution history to include forward sweep. These passages do not discuss translating the blade so far forward as to

reverse the direction of the sweep. This court will not unreasonably construe “a sweep angle that causes the blade to intercept the shock” to include forward sweep in the outer region based on unclear prosecution history particularly when the specification does not allow forward sweep.

UTC also presented extrinsic evidence of computational fluid dynamics (CFD) simulations conducted by its expert, Dr. Yuan Dong, to support its proposed claim construction. It argued that a person of ordinary skill in the art at the time of the invention who conducted a CFD analysis would have seen that under at least some conditions, forward sweep in the outer region was required to intercept the shock. As noted earlier, “the shock” referenced in claim 23 is endwall shock. The record shows that endwall shock is not visible in CFD simulations.

The record shows that one of ordinary skill in the art would not reverse the direction of the sweep angle without a clear motivation to do so. As CFD simulations would not show endwall shock, those simulations would not make one of skill in the art think that claim 23 included forward sweep in the outer region. In addition, in Dr. Dong’s CFD simulations, he translated the outer region in the direction of the relative velocity vector, not toward the axial direction. Therefore, his simulations do not reflect the correct claim construction.

Dr. Dong also equated endwall shock and passage shock even though the specification states that they are unrelated. ’931 application col.1 ll.40–45. As endwall shock is not visible in CFD simulations, Dr. Dong translated the blade until it intercepted the passage shock. Because endwall shock and passage shock are located in different positions within the fan, translation forward to intercept the passage shock would not

yield the same fan blade as translation forward to intercept the endwall shock. Thus, this court does not believe that Dr. Dong's CFD simulations reflect the views of one of ordinary skill in the art in deciding to sweep the blade forward in the outer region to intercept the endwall shock. Moreover, this extrinsic evidence in no way overcomes the intrinsic evidence in the specification that excludes forward sweep in the outer region.

IV.

An interference-in-fact "exists if the subject matter of a claim of one party would, if prior art, have anticipated or rendered obvious the subject matter of a claim of the opposing party and vice versa." 37 C.F.R. § 41.203(a); see Medichem, S.A. v. Rolabo, S.L., 437 F.3d 1157, 1161 (Fed. Cir. 2006). If claim 8 of Rolls-Royce's '077 patent would not have been obvious to one of skill in the art in view of claim 23 of UTC's '931 application, then this record does not show a cause for interference. See Medichem, 437 F.3d at 1161.

Obviousness is a question of law based on underlying factual inquiries including: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art; (3) the differences between the prior art and the claimed invention as perceived before the time of invention; and (4) the extent of any objective indicia of non-obviousness. Monarch Knitting Mach. Corp. v. Sulzer Morat GMBH, 139 F.3d 877, 881 (Fed. Cir. 1998). This court reviews a district court's ultimate determination of obviousness without deference, while reviewing the underlying factual inquiries for clear error. Weatherchem Corp. v. J.L. Clark, Inc., 163 F.3d 1326, 1331 (Fed. Cir. 1998). If a person of ordinary skill, before the time of invention and without knowledge of that invention, would have found the invention merely an easily predictable and achievable variation or combination of

the prior art, then the invention likely would have been obvious. See KSR Int'l Co. v. Teleflex Inc., 550 U.S. 398, 417, 421 (2007). To preclude hindsight in this analysis, this court flexibly seeks evidence from before the time of the invention in the form of some teaching, suggestion, or even mere motivation (conceivably found within the knowledge of an ordinarily skilled artisan) to make the variation or combination. See Ortho-McNeil Pharm., Inc. v. Mylan Labs., Inc., 520 F.3d 1358, 1363–65 (Fed. Cir. 2008); Abbott Labs. v. Sandoz, Inc., 544 F.3d 1341, 1346–53 (Fed. Cir. 2008); Takeda Chem. Indus., Ltd. v. Alphapharm Pty., Ltd., 492 F.3d 1350, 1355–63 (Fed. Cir. 2007).

For the interference analysis, UTC's '931 application is prior art for Rolls-Royce's '077 patent. This court applies the district court's standard of ordinary skill in the art. Under this court's claim construction, UTC's '931 application does not disclose "an outer region between the intermediate region and the fan casing, the outer region defining a forward sweep angle" as required by claim 8 of the '077 patent.

UTC argues that forward sweep in the outer region would have been an easily predictable and achievable variation in view of the disclosure of rearward sweep in UTC's '931 application. UTC uses CFD simulations performed by its expert, Dr. Dong, to show that a person of ordinary skill in the art would have found forward sweep in the outer region a predictable variation. As discussed above, the record shows that those CFD simulations did not show endwall shock. Without some way of detecting benefits in reducing endwall shock or even a reason to seek that reduction in a new way, a researcher or artisan of ordinary skill would not reverse the direction of the sweep angle. Also, those CFD simulations were based on translating the blade toward the direction of the relative velocity vector, not the axial direction, and therefore do not

reflect the proper characteristics of the claimed invention. In addition, the record before invention shows that translation forward in the axial direction may create an unusable fan blade and cause the endwall shock to move behind the passage shock. Thus, the record shows only evidence that the invention might defeat the coincidence of shocks—the benefit of the invention heralded by the '931 application's specification. '931 application col.5 ll.2–4. For all of these reasons, the record contained no evidence that would have suggested to or motivated an ordinarily skilled artisan to sweep the fan blade forward in the outer region. Thus, the record supports the district court's conclusion that this variation would not have been obvious.

Based on the same evidence, UTC argues that an ordinarily skilled artisan would have found it obvious to try to reverse the sweep angle from rearward to forward sweep in the outer region in order to intercept the endwall shock. To determine that an invention would have been obvious to try on the basis of the record before the time of invention, this court has clarified, with respect to inventions requiring selection of a species from a disclosed genus, that the possible approaches and selection to solve the problem must be “known and finite.” See Abbott, 544 F.3d at 1351 (holding as conditions in which “obvious to try” may negate patentability, “the problem is known, the possible approaches to solving the problem are known and finite, and the solution is predictable through use of a known option”). The important question is whether the invention is an “identified, predictable solution” and an “anticipated success.” See id. at 1352. In this case, the broad selection of choices for further investigation available to a person of ordinary skill included any degree of sweep. See Takeda, 492 F.3d at 1359 (holding the invention not obvious to try because the prior art disclosed a broad

selection of compounds that an ordinarily skilled artisan could have selected for further investigation). Also, the record does not show that one of ordinary skill in the art would have any reason to try forward sweep in the outer region at all. A particular course or selection is not obvious to try unless some design need or market pressure or other motivation would suggest to one of ordinary skill to pursue the claimed course or selection. See KSR, 550 U.S. at 421. In other words, one of ordinary skill must have “good reason to pursue the known options within his or her technical grasp.” See id. Because one of ordinary skill could not use CFD simulations to detect endwall shock and no other evidence in the record gives a reason to reverse the sweep angle to intercept that shock, Rolls-Royce’s invention would not have presented itself as an option at all, let alone an option that would have been obvious to try.

In the obviousness analysis, secondary considerations are often some of the best “independent evidence of nonobviousness.” Ortho, 520 F.3d at 1365. The secondary considerations in this case reinforce and substantiate the district court’s correct conclusion of non-obviousness. The district court found that Rolls-Royce’s invention fulfilled a long-felt but unresolved need, achieved commercial success, and also received industry acclaim from the inventor’s peers.

The district court found that Rolls-Royce’s Vice President of Marketing provided compelling testimony about the commercial airline industry’s need for ever quieter, more fuel efficient engines. The district court found that during the time of invention for both the ’931 application and the ’077 patent, the swept fan blade concept was highly promising but remained a mere experimental concept and had never been included in

feasible, commercially-sold engines. The record showed that swept fan blades became unstable during operation, teaching away from their use.

Rolls-Royce built the SCRF blade as a physical embodiment of claim 8. The computer analysis of the SCRF blade predicted an efficiency improvement of 1.8 percent. As documented in an August 18, 1995 internal Rolls-Royce report and explained by the '077 patent's inventor: "In the industry, a half a percent of efficiency would be considered to be a huge gain, a very significant improvement, so 1.8 percent is, is phenomenal really. It's quite a remarkable result. It's three times that half percent."

The district court found that the major breakthrough, however, was that this highly efficient swept fan blade, unlike the prior art, was also stable, due to the forward sweep at the tip. The inventor of the '077 patent testified that: "We were fairly confident that we had at least as good stall margin as a conventional blade, and therefore, we had a workable design."

The parties do not dispute that Rolls-Royce's Trent 8104 engine, incorporating claim 8, was the very first commercially available engine with fan blades with forward-rearward-forward sweep. The district court found that Rolls-Royce satisfied a long-felt need in the industry through the Trent 8104 for a feasible highly swept fan blade engine having the important characteristics of high efficiency, low noise, and stability.

The district court found that the forward-rearward-forward swept fan blade of claim 8 received substantial industry acclaim. Externally, the Trent 8104 engine won the prestigious Flight International Award in Propulsion at the International Paris Air Show. The award recognized specifically the unique fan blade in the Trent 8104. The

Trent 8104 swept fan blades were featured on the cover of the January/February 1999 edition of Flight International with the caption “Trent Sweeps to Higher Thrust.” Rolls-Royce’s Vice President of Marketing testified that “it is quite rare for engines to actually appear on the cover of this sort of magazine. It is usually aircraft.” Internally, Rolls-Royce awarded ’077 patent’s inventor, Rowlands, and his colleague Michael J. Adams (2 out of some 35,000 Rolls-Royce employees) its 1999 Chairman’s Award for Innovation for their work on the fan blade incorporating the invention in claim 8.

Although Rolls-Royce never sold the Trent 8104 engine, that engine was the first commercially available engine with highly swept fan blades. After public awareness of the Trent 8104, the rest of the industry quickly came out with similar versions of the highly swept fan blade engines. Today, the forward-rearward-forward is the industry standard for large civil aircraft engines. Rolls-Royce’s design has been commercially successful. Moreover, Rolls-Royce’s individual market share for swept fan blade engines exceeds 50 percent.

To establish commercial success of the Rolls-Royce invention, Rolls-Royce was required to establish a nexus between the commercial success and the patentably distinct feature of the invention. See Winner Int’l Royalty Corp., 202 F.3d at 1350–51. The district court found that the highly swept fan blades feature was strongly marketed to the airlines. The court found that the improved efficiency and noise characteristics of the fan blade were a major driving force behind the sales of the Rolls-Royce engines that incorporate them. The district court did not clearly err in its secondary consideration findings. Therefore, Rolls-Royce established the required nexus between

engine sales and the invented fan blade design. The secondary considerations cement the district court's conclusion of non-obviousness.

V.

Because the '931 application does not render the '077 patent obvious, this court affirms the district court's holding that the claims of Rolls-Royce's '077 patent are patentable over UTC's '931 application.

AFFIRMED