

How IPR Policies of Telecommunication Standard-Setting Organizations can effectively address patent ambush problem?

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I. Introduction

The conflicts between intellectual property rights (IPRs) and industry common standards in telecommunication sector have raised growing concerns in the industry. These highly controversial issues at play include the embrace of proprietary technologies in standards, excessive royalties for the use of proprietary technologies, the refusal to grant licenses for the use of proprietary technologies.

Many standard-setting organizations (SSOs) have adopted IPR policies in order to address these issues. However, some legal disputes concerning such IPR policies have been raised in recent years, showing that the IPR issues in standardization are far from settled. This article examines the IPR policies of three major telecommunication SSOs under the EU and U.S. law, and concludes that some flaws of these IPR policies may make them fail to address the problems that they have tended to address, and finally it will provide some ways to fix those problems.

The first part of this article provides a background of the standardization of mobile telecommunication technologies and the development of IPR policies by three major telecommunication SSOs. The second examines the requirement of disclosure of essential IPRs in SSO IPR policies. The third part examines the requirement of fair, reasonable and non-discriminatory (FRAND) licensing commitments in SSO IPR policies. Part four provides the conclusion.

II. IPR policies of telecommunication SSOs

This section firstly describes the evolution of mobile technologies and the need to standardize mobile systems, and then it explores the tensions between mobile telecommunication standards and IPRs, finally introduces the IPR policies of three major telecommunication SSOs.

A. The evolution and standardization of mobile telecommunication technologies

The 1st Generation (1G) mobile communication systems were based on analog technology and mainly provided voice communication.¹ The 1G system had its inception in 1978, with the implementation of a trial system in Chicago. In Europe, the 1G system was launched in 1981 in Sweden, Norway, Denmark, and Finland using a technology known as Nordic Mobile Telephony (NMT). Later, several other technologies were developed.² Nevertheless, some drawbacks of the 1G system emerged, such as its low capacity, limited roaming, susceptibility to fraud, and the

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¹ Clint Smith and Daniel Collins, *3G Wireless Networks* (New York: McGraw-Hill, 2002), 27.

² *Ibid.*, 3-4.

loss of mobile connection; solutions to these problems demanded superior technologies.³

In the 1990s, mobile technologies evolved into the 2nd generation. Unlike the 1G systems, 2G systems are digital. The employment of digital technology has a number of advantages, including increased capacity, greater security against fraud, and more advanced services. However, the application of digital technology made telecommunication systems more complex than ever. The mobile telecommunication sector involves many components. The network operators provide communication services, while device manufacturers provide network equipments and handsets, and component manufacturers provide chipsets and parts of network equipments and handsets. For mobile telecommunication systems to function properly, all of those components must seamlessly interface with each other. With the goal being to secure compatibility and interoperability between many components, devices and networks, worldwide standards for mobile telecommunications became crucial, especially considering the need for roaming capabilities among different countries and networks.

However, no single 2G standard was attained. One of the most successful 2G standards, the GSM (Global System for Mobile Communications), was first developed in the 1980s through a pan-European initiative involving the European Commission, telecommunications operators and equipment manufacturers. Later, the European Telecommunications Standards Institute (ETSI) was established and took over this work; it was responsible for GSM standardization. Since the first GSM network was launched in Finland in 1991, the GSM has achieved great success; indeed, soon thereafter most countries in Europe had launched GSM systems. Furthermore, the GSM began to spread outside Europe, and international roaming between the various networks was quickly achieved. Moreover, the GSM has become a global standard rather than just a European standard.⁴ Another successful 2G standard, IS-95CDMA (Code Division Multiple Access), was first introduced by Qualcomm in 1989 in San Diego, California. Later, it was standardized as IS-95 in 1993 by the U.S. Telecommunications Industry Association (TIA).⁵ Since then, many IS-95 CDMA networks have been deployed, particularly in North America, Korea and China. However, the GSM and CDMA standards are not interoperable; namely, equipment and handsets used in one system cannot be used in another.

In the mid-1980s, the International Telecommunication Union (ITU) initiated the concept of 3G for mobile communications in the framework of International Mobile Telecommunications-2000 (IMT-2000)⁶. The 3G systems were intended to provide faster, more accessible communication services, including voice, fax and Internet with seamless global roaming. After more than ten years of work under the leadership of the ITU, in 2000, the technical specifications of 3G systems under the brand IMT-2000 were unanimously approved. However, the proponents of different approaches to 3G technology could not agree on a single standard. This resulted in a variety of approaches to 3G technology consisting of a family of standards. To develop and market the preferred standard, two groups were created, namely, the Third Generation Partnership Project (3GPP) and the 3GPP2. The 3GPP, which was organized by ETSI and American, Chinese, Japanese and Korean official SSOs, works on Universal Mobile Telecommunications System (UMTS) standards, which

³ Ibid., 30.

⁴ Ibid., 6.

⁵ Ibid., 7.

⁶ More information about 3G can be found on ITU's IMT-2000 webpage, <http://www.itu.int/osg/spu/imt-2000/technology.html> (Accessed in August 2008)

are compatible with GSM systems; while the 3GPP2, which was organized by TTA and other 3 Asian official SSOs, works on CDMA2000 standards, which are compatible with IS-95 CDMA systems. Since May 2007, there have been more than 1 billion IMT-2000 subscribers in the world.⁷

During the ITU World Radio Communication Conference and Radio Communication Assembly in 2007, a consensus was reached regarding the establishment of IMT-Advanced system as the name for systems beyond IMT-2000, which are generally recognized as the 4G system. The 4G system may upgrade existing communication networks and is expected to provide access to a wide range of telecommunication services on an “anytime, anywhere” basis and at much higher data rates than previous generations featured. The 4G system is a collection of wireless standards, and so it may contain various standards. Although the 4G system has not been deployed on a large-scale commercial level, the total number of 4G subscribers worldwide, including those for the two most promising 4G technologies LTE and WiMAX, is expected to exceed 90 million in 2013.⁸ Nevertheless, a number of obstacles must be surmounted en route. The history of 2G and 3G has demonstrated, *inter alia*, that the tensions between IPRs and standards may impede the development and implementation of 4G technologies, as demonstrated below.

B. The potential tensions between standards and IPRs

An IPR grants an individual the right to exclusively exploit a piece of knowledge, while a standard intends to identify a common pool of knowledge to be used by everyone.⁹ There is a clear tension between the private character of IPRs and the public nature of standards.¹⁰ Because standards¹¹ define design or performance characteristics that products or services must have, they inevitably cover some claims of patents and software code. When these IPRs are essential to a standard, it is unlikely that one will be able to bypass them in implementing a standard. The situation in the mobile telecommunication sector is especially complex. Because of the high level of research and development (R&D) investments and patenting intensity in this sector, technologies are fragmented into many separate, exclusive

⁷ “Radiocommunication Sector (ITU-R) - ITU global standard for international mobile telecommunications IMT-Advanced,” <http://www.itu.int/ITU-R/index.asp?category=information&rlink=imt-advanced&lang=en>. (Accessed in August 2008)

⁸ “More Than 90 Million 4G Subscribers Worldwide in 2013, says ABI Research | Reuters,” <http://www.reuters.com/article/pressRelease/idUS184192+28-Feb-2008+BW20080228>. (Accessed in March 2009)

⁹ Rudi Bekkers, Bart Verspagen, and Jan Smits, “Intellectual property rights and standardization: the case of GSM,” *Telecommunications Policy* 26, no. 3-4 (April): 172.

¹⁰ Rudi Bekkers, Geert Duysters, and Bart Verspagen, “Intellectual property rights, strategic technology agreements and market structure: The case of GSM,” *Research Policy* 31, no. 7 (September 2002): 1142.

¹¹ According to the International Standard Organization (ISO) definition, standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics to ensure that materials, products, processes and services are fit for their purposes (ISO 2002).

Quality and safety standards define the design or performance characteristics that products must have either to be sold on the market or to obtain “approval,” “certification,” or “listing” by a standard-setting body. Interoperability standards specify whether and how one type of product will be able to fit or communicate with other products (e.g., mobile telecommunication standards, TV transmission standards, or computer operating system interfaces with applications programs). See James J. Anton and Dennis A. Yao, “Standard-Setting Consortia, Antitrust, and High-Technology Industries,” *Antitrust L J* 64 (1995), 247, 248, 262-63.

areas via the ownership of patents or other IPRs on the part of many different firms, thus creating a dense web of IPRs.¹² For instance, the ETSI IPR database shows that there are 4,380 IPRs declared as essential to the GSM standard and 8,666 declared as essential to the UMTS 3G standard in the database.¹³ As a result, when a firm attempts to develop a product or service compliant with a standard, it inevitably infringes on the IPRs of others. Therefore, obtaining a license is generally necessary for any stakeholders to be viable in the market. However, firms that own IPRs essential to a standard may refuse to license them, thereby blocking access to a standard so as to exclude their competitors from the market, or they may take the advantage of their dominant position to charge excessive royalties or impose other unfair conditions on standard implementers, especially when implementers have made considerable investments in implementation. This dynamic is referred to as the “patent hold-up” and “patent ambush” problem.¹⁴ The GSM spurred one of the first cases in which a serious clash occurred between IPRs and standardization, when Motorola only agreed to cross-license essential IPRs among the other four biggest essential IPR holders so that all but these four companies were blocked from entering the market at an early stage.¹⁵

Although standard-setting can entail many benefits for the mobile telecommunication sector, it also may facilitate collusion and exclusionary tactics.¹⁶ Because standard-setting involves a group of firms that together select one and exclude any other technical alternatives from the market, it risks a breach of Article 81 of the EC Treaty¹⁷ and Section 1 of the Sherman Act. To reduce antitrust risk as well as to address the patent hold-up and patent ambush problems and thus mitigate pressures from authorities and industry, many SSOs have adopted IPR policies for their members.

C. SSO IPR policies

This section introduces the contents of the IPR policies of three major telecommunication SSOs, namely the ITU, ETSI and TTA. The ITU is an official international SSO in telecommunication, which has taken a leadership in international standardization of mobile telecommunication technologies; the ETSI is officially recognized by the European Union as an European SSO, which has contributed the most successful 2G and 3G mobile telecommunication standards: the GSM and UMTS; the TTA is an accredited American telecommunication SSO, which has contributed the CDMA IS-95 2G standards and the CDMA 2000 3G standard. Since the standards adopted by these three SSOs along with the two partner projects (3GPP and 3GPP2) have been deployed world-wide, their IPR policies can cover mainstream mobile telecommunication technologies in the world.

¹² Carl Shapiro, “Navigating the Patent Thicket: Cross Licensing, Patent Pools, and Standard Setting,” in *Innovation Policy and the Economy* (Adam Jaffe et al., eds., Nat’l Bureau of Econ. Research, 2001), 2001, 120.

¹³ These data were found in ETSI IPR database at <http://webapp.etsi.org/IPR/> (Accessed in April 2009).

¹⁴ About the patent hold-up problem, see Mark A Lemley and Carl Shapiro, “Patent Holdup and Royalty Stacking,” *Texas Law Review* 85 (2006): 1991.

¹⁵ Bekkers, Verspagen, and Smits, “Intellectual property rights and standardization,” 173.

¹⁶ Herbert Hovenkamp, “Standards Ownership and Competition Policy,” *Boston College Law Review* 48 (2007): 87.

¹⁷ Standardization agreements may be caught by article 81(1) insofar as they grant the parties joint control over production and/or innovation, thereby restricting their ability to compete on product characteristics while affecting third parties like suppliers or purchasers of the standardized products.

In 2007, ITU along with other 2 international official SSOs, —ISO (International Organization for Standardization) and IEC (International Engineering Consortium), adopted a harmonized policy to address the inclusion of proprietary technology in standards. The title of this policy is “Common Patent Policy for ITU-T/ITU-R/ISO/IEC”, and it aims to promote early disclosure of essential patents, promote reasonable licensing and attempt to eliminate patent hold-up problems.¹⁸

The policy requires any parties participating in the works of ITU should, from the outset, disclose any known patent or known pending patent application, either their own or of other organizations, to the SSO. When the relevant patents or pending patents are disclosed, the policy demands that essential patent holders agree to negotiate licenses of royalty free or reasonable royalty with other parties on a non-discriminatory basis on reasonable terms and conditions. Such negotiations are left to the parties concerned and are performed outside the ITU. If a patent holder is not willing to comply with the licensing terms, a standard will not include provisions depending on the patent.¹⁹

The ETSI, as one of the leading telecommunication SSOs, first adopted its IPR policy in 1994. The latest version was revised in November 2008. The aim of the ETSI IPR policy is to ensure that an ETSI standard cannot be blocked by the refusal of an IPR holder to grant licenses for the use of its essential IPR, to reduce the possibility that an investment in the preparation, adoption and application of standards might be wasted as a result of the unavailability of an IPR essential to a standard.²⁰

The policy requires each member to inform the ETSI about its own and others’ essential IPRs, particularly when a member submits a technical proposal; however, the members are not obligated to conduct patent searches.²¹ The owner of an essential IPR related to a particular standard is requested to grant irrevocable licenses based on FRAND terms and conditions under such an IPR.²² If the requested undertaking is not permitted, work on the relevant parts of the standard may be suspended until the matter has been resolved.²³ Before the publication of a standard, if an IPR owner is not willing to grant the requested license, a viable alternative technology may be chosen. If no such alternative technology exists, work on the standard will cease, and the ETSI will contact the IPR owners to request that they reconsider.²⁴ If the ETSI becomes aware that the requested licenses are not available from an IPR owner after a standard has been published, it will contact the relevant IPR owner for an explanation and request that the licenses be granted. If the IPR owner refuses the request, the General Assembly will vote to decide whether it will refer the standard to the relevant technical committee²⁵ to modify it so that the IPR is no longer considered essential. If the vote does not succeed, the General Assembly will consult the ETSI Counselors with a view toward finding a solution to the problem; analogously, the General Assembly may request appropriate members to use their good offices to find a

¹⁸ “Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC,” <http://isotc.iso.org/livelink/livelink/fetch/2000/2122/3770791/customview.html?func=ll&objId=3770791&objAction=browse>. (Accessed in August, 2008)

¹⁹ “Common Patent Policy for ITU-T/ITU-R/ISO/IEC,” <http://www.itu.int/ITU-T/dbase/patent/patent-policy.html>. (Accessed in August, 2008)

²⁰ “ETSI Guide on Intellectual Property Rights,” <http://www.etsi.org/WebSite/AboutETSI/IPRsInETSI/IPRsInETSI.aspx>. (Accessed in August, 2008)

²¹ “ETSI Intellectual Property Rights Policy,” para. 4.1, 29 March, 2007.

²² *Ibid.*, para. 6.1.

²³ *Ibid.*, para. 6.2.

²⁴ *Ibid.*, para. 8.1.2.

²⁵ In ETSI, a technical committee is responsible for drafting standard documents.

solution. If these efforts still do not yield a solution, the General Assembly will request that the European Commission see what further action may be appropriate, including the non-recognition of the standard in question.²⁶

Any published ETSI standards will include information pertaining to essential IPRs that has been disclosed to the ETSI prior to publication.²⁷ The ETSI has set up an IPR database containing such declared essential IPR information.

The TIA IPR policy was published and came into effect in March 2005. The TIA IPR policy is very flexible and largely based on voluntary action. For example, TIA encourages but does not require the voluntary disclosure of essential patents and published pending patent applications that may be essential to the observance of TIA standards; it is not responsible for identifying patents for which licenses may be required in connection with any TIA standard or for verifying the legal validity or scope of these patents. In addition, it will not be a party to discussions of any licensing terms or conditions, which are left to the parties involved, nor will it comment on whether the proposed licensing terms or conditions are reasonable or non-discriminatory.²⁸ The essential IPR holders may state that their IPR will be made available to all applicants under terms and conditions that are reasonable and non-discriminatory (RAND), which may or may not include monetary compensation.²⁹

Comparison of the SSO IPR Policies

	What IPRs are required to disclose?	Is patent search required?	Does SSO check disclosure?	What licensing conditions are required?	Does SSO involve any licensing issues?
ITU	patent, known pending patent application	No	No	RF or FRAND	No
ETSI	Include: copyright, patent, utility model, registered design, and applications thereof. Not include: trademarks, trade secrets, confidential information.	No	No, unless the EC or EFTA so require and reasonable expenses are met	FRAND	No
TIA	patent, published pending patent application, software copyrights	No	No	RAND	No

III. Disclosure of Essential IPRs

A. Failure to Disclose Essential IPRs

According to these SSOs IPR policies, members are entitle and even required to disclose their own and any other third parties patents or other IPRs that may be

²⁶ “ETSI Intellectual Property Rights Policy,” para. 8.2.

²⁷ *Ibid.*, para. 7.1.

²⁸ “TIA IPR Policy, in TIA Engineering Manual, 4th edition, March 2005,” <http://www.tiaonline.org/standards/procedures/manuals/engineering.cfm>.

²⁹ *Ibid.*

essential to a pending standard. The SSO members involved in a standard-setting process generally have sufficient motivation to disclose other' essential IPRs if they have knowledge of them. However, these members might intentionally hide their own essential IPR information, and it is also possible that those with large patent portfolios might inadvertently fail to disclose essential IPRs. The hiding of essential IPR may lead IPR holders to avoid FRAND commitments, thereby causing patent ambush problem in the future. Besides of the inadequate disclosure of essential IPRs, over-declaration may occur, with many IPRs declared as essential that actually are not.³⁰ Consequently, SSO IPR databases would be flooded with false declarations. According to research by Goodman and Myers in 2005, only approximately 21% of the declared patents associated with the 3G standards were actually essential.³¹ Two cases regarding the disclosure of essential IPRs to SSOs have highlighted some typical issues pertaining to the early disclosure rules in SSO IPR policies.

1. Rambus case

In 1990, the founders of Rambus filed patent applications claiming the invention of a faster architecture for dynamic random access memory (DRAM). While Rambus was developing a patent portfolio based on its founders' inventions, the Joint Electron Device Engineering Council (JEDEC), —a non-profit SSO, was undertaking the standardization of DRAM technologies. Rambus attended a meeting of technical committee that was working on synchronous DRAM (SDRAM) standards for the JEDEC in 1991 and later officially joined the JEDEC. In 1993, the committee voted on and approved the completed standard. The SDRAM standard includes two of the four technologies over which Rambus asserted patent rights. In 1995, the technical committee was to develop an advanced double data rate (DDR) SDRAM standard. The committee discussed the technological issues at the December 1995 meeting, which was Rambus's last meeting as a JEDEC member. At the last meeting, Rambus held that "no patents that were essential to the manufacture or use of devices complying with any JEDEC standard, and that when JEDEC issued the SDRAM standard Rambus had no pending patent claims that would necessarily have been infringed by a device compliant with that standard."³² Latter Rambus formally withdrew from the JEDEC on June 17, 1996. After Rambus's departure, in 1998 the committee adopted the DDR SDRAM standard, which included all four of the Rambus patents. Starting in 1999, Rambus informed major DRAM and chipset manufacturers that it held patent rights over the technologies included in the JEDEC's SDRAM and DDR SDRAM standards and that the continued manufacture, sale, or use of products compliant with those standards infringed on its rights.

On June 18, 2002, the FTC filed a complaint alleging that Rambus breached JEDEC policies requiring it to disclose patent information related to standardization works and that the disclosures it had made were misleading. Due to this deceptive conduct, the FTC maintained, Rambus had unlawfully monopolized four technology markets in which its patented technologies compete with alternative innovations in addressing technical issues related to DRAM design. The FTC held that Rambus

³⁰ Larry Goldstein and Brian Kearsy, *Technology patent licensing : an international reference on 21st century patent licensing, patent pools and patent platforms* ([Boston]: Aspatore Books, 2004), 34.

³¹ D.J. Goodman and R.A. Myers, "3G cellular standards and patents," in *Wireless Networks, Communications and Mobile Computing, 2005 International Conference on*, vol. 1, 2005, 415-420 vol.1.

³² *Rambus Inc. v. F.T.C.* 522 F.3d 456 C.A.D.C., 2008, 467.

willfully and intentionally engaged in misrepresentations, omissions, and other practices that misled JEDEC members about intellectual property information that was “highly material” to the standard-setting process. The FTC noted that “but for Rambus’s deceptive course of conduct, JEDEC either would have excluded Rambus’s patented technologies from the JEDEC DRAM standards, or would have demanded assurances of reasonable and non-discriminatory license fees, with an opportunity for *ex ante* licensing negotiations.”³³ It was concluded that Rambus’s deception of JEDEC “significantly contributed to its acquisition of monopoly power.”³⁴ The FTC rendered a separate remedial opinion. In the opinion, it decided to compel licensing at “reasonable royalty rates,” which it calculated based on what it believed would have resulted from negotiations between Rambus and manufacturers before the JEDEC committed to the standards.

Rambus appealed to the Court of Appeals for the D.C. Circuit. The Court, however, held that the FTC had failed to demonstrate that the JEDEC would have standardized other technologies had it known the full scope of Rambus’s intellectual property; it stated that Rambus’s conduct had merely enabled it to avoid the JEDEC from obtaining assurances from Rambus regarding RAND licensing terms, such conduct alone was not exclusionary.³⁵ The FTC’s decision was thus reversed. The FTC appealed to the US Supreme Court, but the Court denied it in February 2009.

2. Dell case

In 1992, the Video Electronics Standards Association (VESA), —a non-profit SSO, adopted a computer hardware standard called the VL-Bus standard, which governs information transmission between a computer’s CPU and its peripheral devices. Dell had participated in the standard-setting process. Each of the members voting for the standard was required to affirm that they did not own any IPRs covering the VL-Bus standard. A Dell representative certified in writing that, to the best of his knowledge, this standard proposal “does not infringe on any trademarks, copyrights, or patents” that Dell possessed.³⁶ However, in reality, Dell had obtained a patent covering the standard in 1991. After the adoption of that standard, and after computer manufacturers had sold more than 1.4 million personal computers incorporating the VL-bus, Dell contacted certain VESA members and claimed patent infringement based on the use of the VL-bus standard. The FTC launched an investigation against Dell. The FTC stated that the VESA “would have implemented a different non-proprietary design had it been informed of the patent conflict during the certification process, and where Dell failed to act in good faith to identify and disclose patent conflicts.”³⁷ However, Dell argued that its representative was not aware either of the patent or of the potential infringement at the time of voting and that it did not intentionally and knowingly mislead the VESA. Nevertheless, the FTC was not convinced. In 1995, Dell entered into a consent decree with the FTC. As part of the consent decree, Dell has agreed not to enforce its patent against any implementer of the standard.³⁸ The FTC was of the opinion that Dell’s activities might harm competition and consumers, and the remedy in this case (i.e. not enforcing the patent)

³³ *Ibid.*, 461.

³⁴ *Ibid.*

³⁵ *Ibid.*, 466-467.

³⁶ *In re Dell Computer Corp*, 121 *FTC* 616 (1996), 617.

³⁷ *Ibid.*, 625.

³⁸ *Ibid.*, 623.

was consistent with the equitable estoppel, in which courts precluded patent holders from enforcing patents when they failed to properly disclose the existence of those patents.³⁹ But it also clarified that it was not creating a general rule that inadvertence in the standard-setting process provides a basis for enforcement action, but instead stated that this action was only limited to the special circumstances of this case.⁴⁰

B. Intentionally disclosing fraud IPR information may harm competition

The purpose of disclosure requirement in IPR policies is to request essential IPR holders' assurance of licensing their essential IPRs on FRAND terms and conditions. It would otherwise exclude such IPRs from being incorporated in a pending standard in case the request is refused, and therefore avoid patent ambush. However, either disclosing incorrect IPR information intentionally or inadvertently to a SSO may circumvent these IPR policies. The binding effect of disclosure rules in SSOs IPR policies relies heavily on the legal liability provided by antitrust law and other legal instruments. This session finds that the *Rambus* decision failed to identify the anticompetitive effect of intentionally disclosing fraud IPR information to an SSO and it may provide a reverse incentive for complying with SSOs' IPR policies.

The possession of market power in the relevant market and the willful acquisition or maintenance of that power as distinguished from growth or development as a consequence of a superior product, business acumen, or historic accident may be subject to liability under Section 2 of the Sherman Act.⁴¹ Members of SSOs intentionally disclosing fraud IPR information, thereby rendering their technologies incorporated into a standard, may obtain strong market power well in excess of that the IPRs are supposed to grant. Before an SSO adopts a standard, there is often vigorous competition among different technologies for incorporation into that standard. After implementing a standard, industry members are locked in the standard and the standardized technology starts to dominate.⁴² In the *Rambus* case, 90% of DRAM production was compliant with the standards at issue, and therefore, the technologies adopted in the standards enjoy a similar level of dominance over their alternatives.⁴³ Nonetheless, in *Rambus v. FTC*, the Court of Appeal for the D.C. Circuit held that the JEDEC would have standardized Rambus' technologies in question even if Rambus had disclosed its IPRs. This implies that the firm's monopoly power arose from the technological superiority of Rambus.

The Court however ignores the fact that even though no alternative technology is available as substitute for Rambus technology in the JEDEC standard, Rambus' monopoly power as gained from the JEDEC standards was not inevitable because users would have other options had Rambus disclosed its patents, such as: 1) avoiding including Rambus' technologies in the standards; 2) not adapting any standard; 3) choosing a less advanced standard.⁴⁴ Even though there was no alternative technology available, users would have the option not to use the patented technology so as to

³⁹ *Ibid.*, 625-626.

⁴⁰ *Ibid.*

⁴¹ *United States v. Grinnell Corp.*, 384 U.S. 563, (1966), 570-71.

⁴² *Rambus Inc. v. F.T.C.* 522 F.3d 456 C.A.D.C., 2008, 459.

⁴³ *Ibid.*

⁴⁴ Joel M. Wallace, "Rambus v. F.T.C. in the Context of Standard-Setting Organizations, Antitrust, and the Patent Hold-Up Problem," *Berkeley Technology Law Journal* 24 (2009): 685.

protect themselves from predatory behavior.⁴⁵ In this sense, without deception, Rambus otherwise might not have gained monopoly power.

In addition, the Rambus decision was not consistent with this Court early *Microsoft* decision, in which it does not require proof of the causation by the plaintiff.⁴⁶ In *Microsoft*, the Court held that it could infer causation of anticompetitive conducts and acquisition or maintenance of monopoly power from the fact that a defendant has engaged in anticompetitive conduct that reasonably appears capable of making a significant contribution to maintaining monopoly power in the case of “neither plaintiffs nor the court can confidently reconstruct a product’s hypothetical technological development in a world absent the defendant’s exclusive conduct.”⁴⁷

In addition, the Court also held in *Rambus* case that lawful monopolist’s use of deception simply to obtain higher prices normally had no particular tendency to exclude rivals and thus to diminish competition.⁴⁸ Nevertheless, Rambus charging high royalty to users may finally transfer high cost to end consumers.

Turning a blind eye to the harm to competitive process of those that intentionally conduct fraud to SSOs in order to incorporate their proprietary technologies in a standard and breach their commitments later after the standard has been approved and even implemented, may provide negative incentive for SSOs members to comply with SSOs IPR policies.

C. Dilemmas in dealing with unintentionally disclosing incorrect IPR information

Three reasons make SSO members correctly disclosing essential IPRs very difficult.

Telecommunication technologies always involve intensive patenting activities. Some IPR holders that manage a large patent portfolio may positively join many important standard-setting activities with the intention to influence technology selection. However, the representatives of a member in each SSO, who usually are engineers, may not have sufficient knowledge of their company’s patents. Therefore, they may omit some essential IPRs in their patent portfolio when they make disclosure.

Determining which patent is essential to a pending standard sometimes involves very demanding works. Clause 15.6 of the ETSI IPR policy suggests a definition of an IPR as essential: “essential as applied to IPR means that it is not possible on technical (but not commercial) grounds, taking into account normal technical practice and the state of the art generally available at the time of standardization, to make, sell, lease, otherwise dispose of, repair, use or operate equipment or methods which comply with a standard without infringing that IPR. For the avoidance of doubt in exceptional cases where a standard can only be implemented by technical solutions, all of which are infringements of IPRs, all such

⁴⁵ Joseph Farrell et al., “Standard Setting, Patents, and Hold-Up,” *Antitrust Law Journal* 74 (2007): 615; Wallace, “Rambus v. F.T.C. in the Context of Standard-Setting Organizations, Antitrust, and the Patent Hold-Up Problem,” 685.

⁴⁶ Wallace, “Rambus v. F.T.C. in the Context of Standard-Setting Organizations, Antitrust, and the Patent Hold-Up Problem,” 684.

⁴⁷ *United States v. Microsoft Corp.*, 253 F.3d 34 (D.C. Cir. 2001), 79.

⁴⁸ *Rambus Inc. v. F.T.C.* 522 F.3d 456 C.A.D.C., 2008, 464.

IPRs shall be considered essential.” In *Nokia v. Interdigital*,⁴⁹ Nokia had brought a suit against InterDigital in the English High Court in 2005, alleging that some of InterDigital’s UK patents declared as essential to the UMTS 3G standard were not actually essential to that standard. InterDigital had claimed 29 patents to be essential to the 3G standards to the ETSI according to the ETSI IPR policy. However, by the time the trial occurred, only four remained in contention. After a deeply technical examination and comparison of the standard and the patent claims, the Court found that 3 of 4 declared essential patents were not real essential to the UMTS 3G standard published by the ETSI, only one patent was accepted by the Court as being essential to the 3G standard. This case shows that determining whether a patent is essential to a standard could be very complicated and involves much technological and legal analysis. Furthermore, during standard-setting process, the draft of a standard could be revised frequently. In this regard, determining whether a patent claim will be covered by a pending standard is as hard as hitting a moving target.

Hiding essential IPR information to SSOs may be desirable for IPR holders since it may therefore make SSOs believe these technologies are nonproprietary and make them easily being incorporated into a standard, thereby avoid IPR holders making FRAND commitments. Any SSO members that fail to disclose essential IPR later may claim the failure is unintentional by negligence because it is very hard to distinguish whether the failure is unintentional or intentional.

In Dell case, many SSOs show concerns about the imposing liability on an unintentional failure to disclose a patent may discourage industry cooperation in standard-setting.⁵⁰ Imposing a punishment for such inadvertently disclosing incorrect IPR information might chill to participate in standard-setting, as all participants of SSOs have to review their patent portfolios carefully before their representatives take part in standard-setting process, a participant which has valuable intellectual property to protect may well considered to withdraw from standard-setting. However, some commentators also pointed out chilling participation in standard-setting should not be a problem because participation in standard-setting is motivated by commercial self-interest not charitable or community service.⁵¹ Nevertheless, due to the three reasons mentioned above, the “disclose it or lose it” approach has not been supported by any SSOs.

Besides of incomplete disclosure, over-disclosure may occur. Some SSO members may disclose many IPRs as essential that actually are not. This may bring two benefits to IPR holders: firstly it can largely avoid omission; secondly disclosing some irrelevant IPRs as essential, later those IPR holders may claim royalties from implementing standards. However, when disclosure is over-declared, the information in SSO IPR databases may not reflect the truly essential IPRs in a standard and provides a misleading picture of the ownership status of essential IPRs.⁵² This may significantly distort the market perception of the true ownership of essential IPRs and license expectations for a particular standard.

Not only SSO members but also SSOs should be responsible for failure to disclose (including incomplete disclosure and over-disclosure). In the ETSI IPR policy, there exist no clear standards for disclosure, no requirements to prove

⁴⁹ *Nokia Corporation v. Interdigital Technology Corporation*, (2008) 31 I.P.D. 31,012, [2007] EWHC 3077.

⁵⁰ *In re Dell Computer Corp*, 121 FTC 616 (1996), 635-637.

⁵¹ *Ibid.*, 638.

⁵² Goldstein and Kearsley, *Technology patent licensing*, 35.

essentiality, and no checks regarding whether a declared IPR is actually essential.⁵³ This prevents SSO members from seriously considering disclosure requirements. Furthermore, the claims of a patent usually do not literally match up with the specifications outlined in a standard document; comprehensive and careful search, comparison and analysis of patent claims and standard technical specifications therefore are necessary to decide whether any patents are essential to a standard.⁵⁴ However, the ETSI IPR policy does not require members to do such work and the ETSI itself does not do this unless either EC or EFTA requests that it do so and covers reasonable expenses.⁵⁵ Moreover, the IPR policy as such does not provide any remedies or punishments for hiding essential IPR information, which means that members feel little pressure to correctly disclose their IPR information.

Standard-making processes show that SSOs usually pay much more attention to technological issues than to IPRs; rather IPR issues may largely be ignored by standard-makers. For instance, in the ETSI, technical bodies (such as an ETSI Project, a Technical Committee or an ETSI Partnership Project) are responsible for concrete standard-making.⁵⁶ A technical body may be supported by working groups or specialist task forces, which consist of technical experts working together as a team to produce the ETSI standards.⁵⁷ An ETSI member or a group of members may submit their proposal to a relevant technical committee for approval in order to initiate a working item. If the proposal is approved, the work of drafting a standard begins. As a procedural formality, at every technical body and working group meeting, the Chairman starts with a “Call for IPRs” in either written form or oral form, which serves as a reminder of member obligations under the ETSI IPR Policy.⁵⁸ Nowhere within the entire standard-making process is there an independent stage intended for the scrutiny and discussion of IPR issues related to a pending standard, and there are no IPR experts involved in the standard-making process. The ETSI Guide on IPR Policy clearly states that “Technical Bodies are not the appropriate place to discuss IPR Issues. Technical Bodies do not have the competence to deal with commercial issues. Members attending ETSI Technical Bodies are often technical experts who do not have legal or business responsibilities with regard to licensing issues. Discussion on licensing issues among competitors in a standards making process can significantly complicate, delay or derail this process.”⁵⁹ The ITU and TIA IPR policies also include similar provisions.

⁵³ *Ibid.*, 34-35.

⁵⁴ *Nokia Corporation v. Interdigital Technology Corporation*, (2008) 31 I.P.D. 31,012, [2007] EWHC 3077, para. 25. In this case, the Court introduces how to decide whether a patent is essential to a standard, “when the claim calls for A, and the standard requires B, the right question is not whether A means B, or covers B, or might with hindsight be said to be another example of the genus of which B is also a member, but whether in its context in the specification the skilled man would appreciate that A in the claim encompassed B.”

⁵⁵ “ETSI Intellectual Property Rights Policy,” para. 4.1 and 6.2.

⁵⁶ *ETSI Technical Working Procedures*, 24 November 2008, sec. 1.1, <http://portal.etsi.org/Directives/home.asp>.

⁵⁷ *Ibid.*, sec. 1.10.

⁵⁸ “ETSI Guide on Intellectual Property Rights,” sec. 2.3.2.

⁵⁹ *Ibid.*, para. 4.1.

D. Shall pending patent applications be disclosed?

The ITU patent policy requires members to disclose any known patents and known pending patent applications.⁶⁰ The ETSI IPR policy requires members to disclose patents and patent applications.⁶¹ The TIA requires member to disclose any patents or published pending patent applications.⁶² For SSO members to disclose known patents seems not to be a problem, however to disclose pending patent applications especially unpublished patent applications may be problematic.

SSO Members may deny disclosing pending patent applications since they might be their business secrets. However, one commentator opined that although the very existence of a patent application may sometimes be a valuable secret, in the context of a publicly adopted standard, disclosure only involves the existence and scope of the patent or patent application, not the technical know-how of the invention itself, the legitimate value of this particular secret does not seem very high, thus this is unlikely to be a major concern.⁶³ Although the disclosure of existence and scope of patents, even of published pending patent applications should not be a problem because such information has already been public available, SSO members may have sufficient reasons to oppose disclosing unpublished pending patent applications if they believe disclosure may harm their competitive advantage. Indeed the risk could be real. Firstly, the disclosure of unpublished patent applications may prematurely uncover applicant competitive strategy to its competitors, as Naughton and Wolfram noted “when an SSO participant disclose a patent application, if not only conveys sensitive information to its competitors about what it is doing but also, just as importantly, conveys information about what it is not doing.”⁶⁴ Moreover the disclosure of unpublished patent applications may harm applicant first-mover advantage. Secondly, its competitors may take advantage of the chance to chase and besiege applicant further innovation,⁶⁵ for instance, its competitors may file patent applications that claim some technologies that are precondition for implementing the earlier disclosed unpublished inventions, and its competitors may also file patent applications that claim some technologies that work complementarily with the earlier disclosed unpublished inventions.

Nevertheless, usually pending patent applications may potentially cause patent ambush problem. Firstly, it is hard to identify the existence of pending patent application by normal search. Secondly, the claims of a pending patent application may be modified therefore it may become essential to a standard while the claims in the original filed documents might not be essential. Withholding unpublished patent applications makes applicants be able to avoid making FRAND commitments and meanwhile prevent their proprietary technologies from being excluded from a standard, thereby cause patent ambush problem in the future. In most cases it is desirable for these applicants to withhold such information, as in *Rambus* case.

⁶⁰ “Common Patent Policy for ITU-T/ITU-R/ISO/IEC,” sec. 1.

⁶¹ “ETSI Guide on Intellectual Property Rights,” sec. 1.3.

⁶² “TIA IPR Policy, in TIA Engineering Manual, 4th edition, March 2005,” sec. 1.2.

⁶³ Mark A. Lemley, “Intellectual property rights and standard-setting organizations,” *California Law Review* 90 (2002): 1443.

⁶⁴ Michael C. Naughton, “The antitrust risks of unilateral conduct in standard setting, in the light of the FTC s case against Rambus Inc.,” *Antitrust Bulletin* 49, no. 3 (2004): 767.

⁶⁵ *Ibid.*, 764-765.

E. Negative disclosure may fix the problems

Negative disclosure may fix the problems identified in the previous sections. Negative disclosure consists in four main requirements. First, it requires all members of an SSO to agree to grant license of their essential IPRs based on FRAND terms and conditions except in the case of exceptional circumstances. Second, at the beginning of standard-making process, there is no general requirement for members to disclose their essential IPRs. Third, as one of the exceptional circumstances, any members that would not grant licenses of their essential IPRs based on FRAND terms and conditions are required to disclose these essential IPRs after a standard draft is completed and before the draft is submitted for approval, otherwise, FRAND terms and conditions will apply. Finally, all members disclose their essential IPRs for the licensing purpose after the final standard draft has been approved. This negative disclosure model has been adopted by DVB standardization.⁶⁶

The rationality of the negative disclosure is that if a patent is so significant that its owner would not even grant license of using it on FRAND terms and conditions, the owner should be aware of such patent. If an essential patent is ignored to disclose by negligence, FRAND terms and conditions still apply to the patent licensing, and the owner does not lose patent rights and it still has chance to receive reasonable royalties from those practicing the patent while implementing a standard. Whether to disclose an unpublished pending patent application or not is at members' discretion, either way does not cause patent ambush problem, and meanwhile technology contributor rights and interests are well respected. The advantages of this model consist in that it make SSOs focus on technological issues, and SSO members be responsible for disclosing their essential IPRs, and it can completely avoid fraud and omission in disclosure procedure. The disclosure takes place after a standard draft has been fixed, so it is reasonable for SSO members to consider the IPR issues related a pending standard at this stage. However, one flaw of this approach is that standard-setting may only focus on choosing best technologies but miss some nonproprietary technologies.

IV. FRAND Commitments

SSO IPR policies require the owner of an essential IPR related to a particular standard to grant irrevocable licenses on FRAND terms and conditions under such IPR. However, the negotiation of licenses is left to parties concerned, and is performed outside SSOs. This section exploits whether there exist practicable rules for determining FRAND terms and conditions as well as the legal effects of FRAND terms and conditions from the EU and U.S. perspectives.

A. FRAND licensing under EU Law

In the EU, a dominant firm is obligated to deal with its customers under fair, reasonable and non-discriminatory conditions.

⁶⁶ C. Eltzroth, "IPR policy of the DVB project: Negative disclosure, FR&ND arbitration unless pool rules OK part 1," *International Journal of IT Standards and Standardization Research* 6, no. 2 (2008): 21-38.

1. Fairness

Article 82(a) of the EC Treaty expressly condemns unfair conditions induced by a dominant firm. In *Tetra Pak II*,⁶⁷ Tetra Pak specialized in the packaging of liquid and semi-liquid foods in cartons; moreover, it held a dominant position in the market. The terms on which Tetra Pak dealt with its customers included a number of customer obligations that had no link to the purpose of its contracts and distorted the very nature of those contracts; these were found by the European Commission to be unfair.⁶⁸ The conditions included placing limitations on the purchasers' use of the machines, committing purchasers to the use of Tetra Pak's repair and maintenance services, and reserving for Tetra Pak the right to make surprise inspections.⁶⁹ The Court of First Instance (CFI) and the European Court of Justice (ECJ) upheld the Commission's findings.

In *Amministrazione Autonoma dei Monopoli di Stato (AAMS) v. Commission*,⁷⁰ the CFI affirmed the Commission's finding that AAMS, a dominant wholesale distributor of cigarettes in Italy, had abused its dominant position because its nonnegotiable terms regarding unilateral distribution imposed on foreign producers were unfair; these included a limit on the introduction of new cigarette brands onto the market, a maximum quantity of new cigarette brands, a maximum monthly quantity of cigarettes allowed on the market, and restrictions on the packaging of cigarettes.

The *Der Grüne Punkt-Duales System Deutschland GmbH(DSD) v. Commission*⁷¹ case related to a German ordinance, according to which manufacturers and distributors of packaging are required to take back and recover the packaging that they had put on the German market. DSD ran the only nationwide system for packaging collection, sorting and recovery under its Green Dot trademark. To use DSD's service, packaging manufacturers and distributors had to place the Green Dot logo on their packaging. The manufacturers and distributors were obliged to pay DSD a fee that covered the costs of the collection, sorting and recovery of the packaging taken back by DSD and the associated administrative costs. The Commission found that the operation of the DSD system amounted to a breach of Article 82 because DSD was claiming the full fees for all the packaging on which the Green Dot logo was placed even though the actual collection and recycling services were provided by its competitors. Hence, the Commission found the conduct of DSD to be clearly abusive, insofar as it sought to impose unfair prices on participating firms and to prevent competitors from entering the German market in question.

In summary, although the Commission and Courts have not explicitly defined what fairness is, it is clear from case law that fairness means that a dominant firm does not exploit its dominant position by imposing irrelevant obligations on its customers at the expense of customers. The end result should be acceptable to both parties, and should be an outcome that they can live with.⁷² The unfair conditions in

⁶⁷ 92/163/EEC: Commission Decision of 24 July 1991 relating to a proceeding pursuant to Article 86 of the EEC Treaty (IV/31043 - Tetra Pak II) OJ L 72, 18.3.1992, p. 1-68.

⁶⁸ Ibid., para. 106.

⁶⁹ Ibid., para. ANNEX II.

⁷⁰ Case T-139/98, *Amministrazione Autonoma dei Monopoli di Stato(AAMS) v. Commission* [2001] ECR II-3413.

⁷¹ Case C-385/07 P *Der Grüne Punkt-Duales System Deutschland GmbH v. Commission*, 16 July 2009.

⁷² Goldstein and Kearsy, *Technology patent licensing*, 27.

practices may take a variety of forms and therefore should be identified on a case-by-case basis.

2. Reasonableness

Reasonableness under FRAND terms mainly relates to royalty level. Article 82(a) of the EC Treaty prohibits “directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions.” In *United Brands v. Commission*,⁷³ the ECJ held that “the imposition by an undertaking in a dominant position directly or indirectly of unfair purchase or selling prices is an abuse to which exception can be taken under Article [82] of the Treaty.”⁷⁴ The Court also noted that “charging a price which is excessive because it has no reasonable relation to the economic value of the product supplied would be such an abuse.”⁷⁵

In *Scandlines Sverige v. Port of Helsingborg*,⁷⁶ the Commission clearly described the approach to deciding the reasonableness of a price charged by a dominant firm in the *United Brand* case. The first question to be considered is whether the difference between cost and price is excessive; then, if it is, the second question is whether the price is unfair in itself or in comparison to those of competing products. The Commission subsequently explained that “an analysis of excessive or unfair pricing abuse must focus on the price charged, and its relation to the economic value of the product. While a comparison of prices and costs, which reveals the profit margin of a particular company may serve as a first step in such an analysis, this in itself cannot be conclusive as regards the existence of an abuse.”⁷⁷

However, the Courts have never suggested the level at which the profit would become excessive.⁷⁸ Assessing the economic value and cost of an essential IPR is extremely difficult especially when one takes into account the past research costs of IPR holders that did not result in commercially exploitable products.⁷⁹ The costs incurred by essential IPR holders that were sunk in failed R&D activities may be considered part of the cost of creating the essential IPRs. From a policy perspective, this arrangement is very important in inducing the risk-taking that produces innovation; as one scholar pointed out, “the patent system we have is based on something of a lottery principle, forcing inventors to bear their own losses from failure but holding out the prospect of monopoly in the event of success.”⁸⁰

Furthermore, cost is not the sole element at play in the calculation of reasonable price. The EC has rejected the method that simply adds a margin to the approximate cost of production to determine the economic value of a product or service. Rather, economic value must be determined with regard to the particular circumstances of the case and by taking into account non-cost-related factors.⁸¹ In the

⁷³ *Case C-27/76, United Brands v. Commission of the European Communities*, [1978] ECR 207.

⁷⁴ *Ibid.*, para. 248.

⁷⁵ *Ibid.*, para. 249-250.

⁷⁶ *Case COMP/A 36.568/D3 – Scandlines Sverige AB v. Port of Helsingborg*, Decision of 23 July 2004.

⁷⁷ *Ibid.*, para. 214.

⁷⁸ Alison Jones and Brenda Sufirin, *EC Competition Law*, 3rd ed. (Oxford: Oxford University Press, 2007), 588.

⁷⁹ *Ibid.*, 590.

⁸⁰ Phillip Areeda and Louis Kaplow, *Antitrust Analysis: Problems, Text, Cases*, 5th ed. (Aspen Publishers, 1997), 430.

⁸¹ *Case COMP/A 36.568/D3 – Scandlines Sverige AB v. Port of Helsingborg*, Decision of 23 July 2004., para. 232.

English case *Attheraces Ltd v. The British Horseracing Board (BHB)*,⁸² the Court of Appeals also held that there is nothing in Article 82 or case law to suggest that the index of abuse is the extent of departure from a cost+ criterion. The Court indicated that “exceeding cost+ is a necessary, but in no way a sufficient, test of abuse of a dominant position.” The Court cited ECJ case law and indicated that Article 82 was not a general provision for the regulation of prices; rather, it sought to prevent the abuse of dominant market positions with the object of protecting and promoting competition. The Court also emphasized that a fair price was one that would represent or reflect the economic value of the product supplied as indicated in the *United Brands* case. In this regard, the economic value approach might serve an important function in protecting the interests of essential IPR holders and prevent disregarding the real value of essential IPRs.

Some cases have suggested possible benchmarks to decide reasonable royalty level. The assumed price that would have resulted from negotiations between licensors and licensees before standardization could serve a benchmark. This would be in accordance with the ECJ’s opinion in the *United Brand* case that “it is advisable to ascertain whether the dominant undertaking has made use of the opportunities arising out of its dominant position in such a way as to reap trading benefits which it would not have reaped if there had been normal and sufficiently effective competition.”⁸³

In *Deutsche Post*,⁸⁴ the Commission suggested that when judging whether a price was excessive in a market open to competition, the normal test was to compare the prices of the dominant operator with those charged by competitors. In this regard, the established royalties charged by others based on an essential IPR with an equal position in the same standard, or the royalty level of a competing standard can be employed as a benchmark.

It is also possible to compare the prices charged by a dominant firm in different countries or different areas, as long as the differences of transaction costs in different markets are taken into account. In *Ministere Public v. Tournier*, the ECJ held that “when an undertaking holding a dominant position imposes scales of fees for its services which are appreciably higher than those charged in other Member States and where a comparison of the fee levels has been made on a consistent basis, that difference must be regarded as indicative of an abuse of a dominant position.”⁸⁵

3. Non-discriminatory

The ability of imposing discriminated conditions implies existence of market power because in a competitive market the customers who are disfavored, i.e., charged the higher price, will be able to take their custom elsewhere.⁸⁶ Yet, usually a pure licensor (even one with monopoly power) does not have anticompetitive motivation for engaging in discrimination.⁸⁷ However, when an essential IPR holder

⁸² *Attheraces Ltd. v. British Horse Racing Board*, [2007] EWCA Civ 38.

⁸³ *Case C-27/76, United Brands v. Commission of the European Communities*, [1978] ECR 207, para. 249-250.

⁸⁴ *Commission Decision of 25 July 2001 relating to a proceeding under Article 82 of the EC Treaty (COMP/C-1/36.915 — Deutsche Post AG — Interception of cross-border mail)* [2001] OJ L331/40, 159-165.

⁸⁵ *Case C-395/87, Ministère public v. Jean-Louis Tournier* [1989] ECR 2521, 38.

⁸⁶ Jones and Sufin, *EC Competition Law*, 441.

⁸⁷ Daniel G. Swanson and William J. Baumol, “Reasonable and Nondiscriminatory (Rand) Royalties, Standards Selection, and Control of Market Power,” *Antitrust Law Journal* 73 (2005): 26.

competes with other competitors in a neighboring market, in which the technology is necessary for its IPR holder and other competitors producing a product or providing service compliant with a standard, the licensor may discriminate against those competitors in licensing to disadvantage them and favor its own markets for those products or services.⁸⁸

Article 82(c) of EC Treaty prohibits a dominant firm from applying dissimilar conditions to equivalent transactions with other trading parties such that these conditions place certain parties at a competitive disadvantage. Some ECJ cases indicate that when a firm in a dominant position grants quantity discounts⁸⁹ or charges different prices⁹⁰ to different customers, this could be regarded as indicative of the abuse of the firm's dominant position. In such a case it is for the firm in question to justify the difference through reference to objective dissimilarities between the situations at hand. Such differential treatment must not result in the application of dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage.⁹¹ The assessment of justification has to be made on the basis of the whole of the circumstances of the case.⁹² In *British Airways v. Commission*,⁹³ the bonus and commission scheme was ruled to breach Article 82(c) because it wrongly differentiated between the travel agents and thus had the potential to exclude competitors; also, the scheme was not justified from an economic standpoint.

The German Supreme Court has closely scrutinized a case involving licensing patents essential to an industry standard under different treatments. In *Standard-Spundfass*,⁹⁴ four German drum manufacturers, including the plaintiff and the companies K, S and L, presented proposals for a standard of synthetic drums with improved draining characteristics to the Association of the Chemical Industry (VCI). The plaintiff's proposal, which was based on the technical specifications of its patent, was chosen to integrate into the VCI standard. Any drums that were not in compliance with the standard were impossible to sell in German market. However, to manufacture the drums to meet VCI standards, it was necessary to infringe on the disputed patent. The plaintiff granted the three above-named companies royalty-free licenses for the disputed patent. In addition, it granted paid licenses to other drum manufacturers situated in other EU-member states. However, it refused a request for a license from the parent company of the defendant. The German Supreme Court firstly noted "the different treatment of the licensees that lies in the grant of some paid licences and some free licences for the patent need not automatically be considered unjustified", and a dominant firm should especially not be prevented from reacting differently to different market conditions.⁹⁵ However, the court also pointed out that the dominant firm was obligated to show that there was an objectively justifiable reason for the unequal treatment.⁹⁶ In determining whether unequal treatment was objectively

⁸⁸ *Ibid.*

⁸⁹ *Case C-163/99 Portugal v. Commission* [2001] ECR I-2613, [2002] 2 CMLR 1319.

⁹⁰ *Case C-395/87, Ministère public v. Jean-Louis Tournier* [1989] ECR 2521, para. 38.

⁹¹ *Case C-163/99 Portugal v. Commission* [2001] ECR I-2613, [2002] 2 CMLR 1319, para. 50.

⁹² *Case C-322/81, Nederlandsche Banden-Industrie Michelin NV v. Commission* [1983] ECR 3461, 73.

⁹³ *Case C-95/04 P, British Airways v. Commission*, [2007] ECR I-2331.

⁹⁴ German Federal Supreme Court, "Standard Tight-Head Drum (Standard-Spundfass)," *IIC* 36, no. 6 (2005).

⁹⁵ *Ibid.*, 748.

⁹⁶ *Ibid.*, 747. Sec. 20(3) of the Act against Restraints of Competition states that dominant undertakings and associations of undertakings within the meaning of subsection (1) shall not use their market

justified, the court focused on whether the relatively less favorable treatment of the concerned firms was a pro-competitive balancing of interests, or whether it was arbitrary or stemmed from considerations and intentions that had nothing to do with sound economic or entrepreneurial behavior. In addition, the firms affected by such unequal treatment could not be impaired in their competitiveness by the exercise of the dominant power.⁹⁷

B. FRAND licensing under U.S. Law

1. FRAND licensing under antitrust law

In the U.S, courts traditionally are reluctant to tackle the price issue.⁹⁸ Usually U.S. courts refuse to set a ceiling for patent owners to charge royalty. In *W.L. Gore & Assoc. v. Carlisle Corp.*,⁹⁹ the court rejected the claim that unreasonably high royalties constitute patent misuse. In *Brulotte v. Thys Co.*,¹⁰⁰ the court noted that “a patent empowers the owner to exact royalties as high as he can negotiate with the leverage of that monopoly.” U.S. courts have generally rejected the notion that charging differential royalties is a violation of law even when the licensor is a true monopolist. In *USM Corp. v. SPS*, which involves the lawfulness of differential patent royalties under antitrust and patent-misuse principles, the Court of Appeals for Seventh Circuit held that “there is no antitrust prohibition against a patent owner’s using price discrimination to maximize his income from the patent.”¹⁰¹ However, the Court did not exclude the possibility that “price discrimination” might in a particular case be condemned as an attempt to monopolize or as an act of monopolization under Section 2 of the Sherman Act, or as violation of the Rule of Reason under Section 1 of that Act.¹⁰² To meet the requirement of the Rule of Reason, anticompetitive effect has to be present.

2. FRAND licensing under patent law

According to the U.S. patent law, “Upon finding for the claimant the court shall award the claimant damages adequate to compensate for the infringement, but in no event less than a reasonable royalty for the use made of the invention by the infringer.”¹⁰³ In patent infringement case, a patent holder must satisfy 4 prong conditions to prove actual damages, e.g., lost profits. If a plaintiff fails to do so, actual damage claim will not be supported; instead, a reasonable royalty may be awarded.¹⁰⁴ U.S. courts have defined reasonable royalty in early case as an amount “which a person, desiring to manufacture and sell a patented article, as a business proposition,

position to cause other undertakings in business activities to grant them preferential terms without any objective justification.

⁹⁷ *Ibid.*, 748.

⁹⁸ *United States v. Trans-Missouri Freight Association*, 166 U.S. 290 (1897), 332-333.

⁹⁹ *W. L. Gore & Assoc., Inc. v. Carlisle Corp.*, 529 F.2d 614 (3d Cir. 1976), 622-623.

¹⁰⁰ *Brulotte v. Thys Co.*, 379 U.S. 29 (1964), 33.

¹⁰¹ *USM Corp. v. SPS Technologies, Inc.* 694 F.2d 505 (7th Cir, 1982), 512-513.

¹⁰² *Ibid.*, 512.

¹⁰³ 35 U.S.C. §284

¹⁰⁴ *Panduit Corp. v. Stahl Bros. Fibre Works, Inc.*, 575 F.2d 1152 (6th Cir. 1978), 1158. The *Panduit* test requires that a patentee establish: (1) demand for the patented product; (2) absence of acceptable non-infringing substitutes; (3) manufacturing and marketing capability to exploit the demand; and (4) the amount of the profit it would have made.

would be willing to pay as a royalty and yet be able to make and sell the patented article, in the market, at a reasonable profit.”¹⁰⁵

Recent Federal Circuit Court decisions show that there are three ways to decide reasonable royalties. In *Monsanto Co. v. McFarling*, the Court of Appeals for Federal Circuit noted that “an established royalty is usually the best measure of a “reasonable” royalty for a given use of an invention because it removes the need to guess at the terms to which parties would hypothetically agree. When the patentee has consistently licensed others to engage in conduct comparable to the defendant’s at a uniform royalty, that royalty is taken as established and indicates the terms upon which the patentee would have licensed the defendant’s use of the invention.”¹⁰⁶ In recent *Lucent Technologies, Inc. v. Gateway, Inc and Microsoft Corp.*,¹⁰⁷ the Court of Appeals for Federal Circuit identified two approaches to calculating reasonable royalty. The first, the analytical approach, focuses on the infringer’s projections of profit for the infringing product. It subtracts the infringer’s usual or acceptable net profit from its anticipated net profit realized from sales of infringing devices.¹⁰⁸ The second, more common approach, called the hypothetical negotiation or the “willing licensor-willing licensee” approach, attempts to ascertain the royalty upon which the parties would have agreed had they successfully negotiated an agreement just before infringement began.¹⁰⁹ In *Lucent* case, both parties had agreed to adopt the hypothetical negotiation approach, then the Court chosen and reviewed 8 factors of *Georgia-Pacific* to decide the reasonable royalty in this case.¹¹⁰ The Court noted that

¹⁰⁵ *Goodyear Tire and Rubber Co. v. Overman Cushion Tire Co.*, 95 F.2d 978 (6th Cir. 1937), 984; *Rockwood v. General Fire Extinguisher Co.*, 2 Cir., 1930, 37 F.2d 62, 66.

¹⁰⁶ *Monsanto Co. v. McFarling*, 488 F.3d 973 (Fed.Cir.2007), 978-979.

¹⁰⁷ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1308-1309.

¹⁰⁸ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1324; *TWM Mfg. Co. v. Dura Corp.*, 789 F.2d 895 (Fed.Cir.1986), 899.

¹⁰⁹ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1324; *Radio Steel & Mfg. Co. v. MTD Prods., Inc.*, 788 F.2d 1554 (Fed.Cir.1986), 1557.

¹¹⁰ *Pacific Corp. v. U.S. Plywood Corp.*, 318 F.Supp. 1116 (S.D.N.Y.1970), 1120. In this case, the Court identified a comprehensive list of factors relevant to the determination of the amount of a reasonable royalty for a patent license, which are: (1) The royalties received by the patentee for the licensing of the patent in suit, proving or tending to prove an established royalty. (2) The rates paid by the licensee for the use of other patents comparable to the patent in suit. (3) The nature and scope of the license, as exclusive or non-exclusive; or as restricted or non-restricted in terms of territory or with respect to whom the manufactured product may be sold. (4) The licensor's established policy and marketing program to maintain his patent monopoly by not licensing others to use the invention or by granting licenses under special conditions designed to preserve that monopoly. (5) The commercial relationship between the licensor and licensee, such as, whether they are competitors in the same territory in the same line of business; or whether they are inventor and promoter. (6) The effect of selling the patented specialty in promoting sales of other products of the licensee; that existing value of the invention to the licensor as a generator of sales of his non-patented items; and the extent of such derivative or convoyed sales. (7) The duration of the patent and the term of the license. (8) The established profitability of the product made under the patent; its commercial success; and its current popularity. (9) The utility and advantages of the patent property over the old modes or devices, if any, that had been used for working out similar results. (10) The nature of the patented invention; the character of the commercial embodiment of it as owned and produced by the licensor; and the benefits to those who have used the invention. (11) The extent to which the infringer has made use of the invention; and any evidence probative of the value of that use. (12) The portion of the profit or of the selling price that may be customary in the particular business or in comparable businesses to allow for the use of the invention or analogous inventions. (13) The portion of the realizable profit that should be credited to the invention as distinguished from non-patented elements, the manufacturing process, business risks, or significant features or improvements added by the infringer. (14) The opinion testimony of qualified experts. (15) The amount that a licensor (such as the patentee) and a licensee (such as the infringer) would have agreed upon (at the time the infringement began) if both had been

“we need not identify any particular Georgia-Pacific factor as being dispositive. Rather, the flexible analysis of all applicable Georgia-Pacific factors provides a useful and legally-required framework for assessing the damage award in this case.”¹¹¹

3. Royalty stacking and entire market value

In telecommunication sector, technologies are highly fragmented, as Bekkers shows there are 1227 unique and essential patents to the UMTS 3G standard distinguished from all 6313 declared essential patents from the ETSI IPR database.¹¹² As a result, a single device may embrace hundreds of patents. So even each patent owner charges a small amount of license fees, finally the aggregate license fees may be prohibitively high. This phenomenon is referred as “royalty stacking”.¹¹³

When a device embrace some patented apparatuses with unpatented components, U. S. courts have applied a formulation known as the “entire market value rule” to determine whether such components should be included in the damage computation, whether for reasonable royalty purposes.¹¹⁴ Pursuant to the entire market value rule, even though a patented feature makes up only a portion of the product, the entire market value rule permits recovery of damages based on the value of the entire product containing several features if the patent-related feature is the basis for customer demand.¹¹⁵

The entire market value rule has been criticized for its exacerbating royalty stacking problem.¹¹⁶ Nevertheless, the Federal Circuit refuted the argument that “the entire market rule should have little role in reasonable royalty law.”¹¹⁷ The Court pointed out that “such general propositions ignore the realities of patent licensing and the flexibility needed in transferring intellectual property rights. The evidence of record in the present dispute illustrates the importance the entire market value may have in reasonable royalty cases.”¹¹⁸ And the Court added that “there is nothing inherently wrong with using the market value of the entire product, especially when there is no established market value for the infringing component or feature, so long as the multiplier accounts for the proportion of the base represented by the infringing component or feature.”¹¹⁹ Moreover the Court explained that since all running royalties have at least two variables: the royalty base and the royalty rate, the base used in a running royalty calculation can always be the value of the entire commercial embodiment, as long as the magnitude of the rate is within an acceptable range.¹²⁰ It implies that when the value of the entire product at issue is accounted as royalty base,

reasonably and voluntarily trying to reach an agreement; that is, the amount which a prudent licensee—who desired, as a business proposition, to obtain a license to manufacture and sell a particular article embodying the patented invention—would have been willing to pay as a royalty and yet be able to make a reasonable profit and which amount would have been acceptable by a prudent patentee who was willing to grant a license.

¹¹¹ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1335.

¹¹² Rudi Bekkers and Joel West, “The limits to IPR standardization policies as evidenced by strategic patenting in UMTS,” *Telecommunications Policy* 33, no. 1-2 (February): 83.

¹¹³ Lemley and Shapiro, “Patent Holdup and Royalty Stacking,” 1991.

¹¹⁴ *Rite-Hite Corp. v. Kelley Co.*, 56 F.3d 1538 (Fed. Cir. 1995), 1549.

¹¹⁵ *Ibid.*

¹¹⁶ Brian J Love, “Patentee Overcompensation and the Entire Market Value Rule,” *Stanford Law Review* 60 (2007): 280.

¹¹⁷ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1339.

¹¹⁸ *Ibid.*

¹¹⁹ *Ibid.*

¹²⁰ *Ibid.*, 1338-1339.

the applied royalty rates may be reduced compared to the scenario when only patented components accounted as royalty base. In addition, one factor that restrains the application of the entire market value rule is that a patentee must approve that the patents-related feature is the basis for customer demand.¹²¹

C. Remarks on FRAND commitments

FRAND commitments may bring three benefits to the industry.

First, it may facilitate antitrust action against the behaviors that have anticompetitive effect by leveraging essential IPRs.

In EU, owners of essential IPRs in a prevalent standard may have an obligation to grant license of using that IPR under FRAND terms and conditions, even though it has not made FRAND commitments to a SSO, as long as its dominant position can be established. However, FRAND commitments do have some benefits. Relying on FRAND commitments, potential licensees need not to prove the existence of a dominant position, to define the relevant market, to prove the IPR at issue is essential to the relevant standard etc.

Since the U.S. antitrust law does not require a dominant firm to deal with its customers under FRAND conditions, FRAND commitments in SSOs IPR policies have significant meaning for potential licensees to avoid being ambushed by essential IPR holders. In *Broadcom v. Qualcomm*,¹²² Broadcom filed an action against Qualcomm in July, 2005, alleging that Qualcomm had induced the ETSI to include its proprietary technology in the UMTS standard by deception to obey the ETSI IPR policy, but then breached the agreement by licensing its technology on non-FRAND terms as well as ignoring its FRAND commitments to the ETSI by demanding discriminatorily higher (i.e., non-FRAND) royalties from competitors and customers using chipsets not manufactured by Qualcomm. The Third Circuit Court of Appeals held that “(1) in a consensus-oriented private standard-setting environment, (2) a patent holder’s intentionally false promise to license essential proprietary technology on FRAND terms, (3) coupled with an S[SO]’s reliance on that promise when including the technology in a standard, and (4) the patent holder’s subsequent breach of that promise, is actionable anticompetitive conduct... Deceptive FRAND commitments, no less than deceptive nondisclosure of IPRs, may result in such harm [of competitive process].”¹²³ Thus, FRAND commitments can provide a legal basis for antitrust action that standard implementers can rely on against patent hold-up and patent ambush.

Secondly, FRAND licensing may draw a balance between essential patent owners and standard implementers in standardization context because on the one hand focusing on the economic value of an essential patent at issue may well protect technology contributor interests, and on the other hand, considering relevant factors to decide what both parties would have agreed to, had there not existed standard lock-in, may protect standard implementers from patent ambushing and patent overexploiting. A commentator suggests applying patent misuse rule to patent ambush in standardization context therefore make patents at issue unenforceable.¹²⁴ However,

¹²¹ *Ibid.*, 1336.

¹²² *Broadcom Corp. v. Qualcomm Inc.* 501 F.3d 297 (3rd Cir. 2007).

¹²³ *Ibid.*, 314.

¹²⁴ Apostolos Chronopoulos, “Patenting Standards - A Case for US Antitrust Law or a Call for Recognizing Immanent Public Policy Limitations to the Exploitation Rights Conferred by the Patent Act?,” *IIC* 40, no. 7 (2009): 812-815.

this proposal disregards the value of a patented technology and its contribution to the industry. There is no legitimate basis to conduct such expropriation because it would arbitrarily harm those innovative firms and chill standard-setting process. In FTC Rambus decision, while FTC confirmed Rambus's deception of the JEDEC significantly contributed to its acquisition of monopoly power, thereby breaching Section 2 of the Sherman Act, it did not simply compel Rambus to license its relevant patents royalty-free; instead, FTC decided to compel licensing at reasonable royalty rates, which it calculated based on what it believed would have resulted from negotiations between Rambus and manufacturers before the JEDEC had committed to the standards.¹²⁵

FRAND commitments have been criticized as lack of certainty and clarity. Yet those criticisms ignore the realities of patent licensing and the flexibility needed in transferring intellectual property rights. Even though in a generally recommended licensing negotiation *ex ante* standardization in dealing with patent hold-up and patent ambush, the licensing terms and conditions still rely on negotiations and will not be in certainty before both parties can enter into an agreement. Reasonable royalty analysis necessarily involves an element of approximation and uncertainty especially when to determine the correct value of the patented invention which is only one part or feature among many, and to ascertain what the parties would have agreed to in the context of a patent license negotiation.¹²⁶ The U.S. Federal Circuit noted that "licensors of patented technology often license an invention for more or less than its true economic value. Such is the inherent risk in licensing intangible assets that may have no establishment market value."¹²⁷ Therefore, FRAND licensing is not less certainty than any other commercial licensing schemes. FRAND licensing is a reasonable measure to address patent-ambush problem in standardization context.

To determine reasonable royalty level, EU law and the U.S. law seem to both agree to consider what the value of the invention at issue, and what both parties would have agreed to in the context of a patent licensing negotiation.¹²⁸ However, in standardization context, the supposed timing when parties would have entered into a licensing agreement must be prior to the standardization of relevant technologies rather than to the outset of infringement because when infringement started, the relevant technologies may have already been dominant in the market.

Finally, FRAND commitments are expected to remove IPR holders' threat of injunction relief, thereby avoiding patent-ambush problem. In *eBay Inc. v. MercExchange, L.L.C.*, the U.S. Supreme Court noted that "the creation of a right is distinct from the provision of remedies for violations of that right."¹²⁹ Several Judges in the consent opinions pointed out that "for these firms, an injunction, and the potentially serious sanctions arising from its violation, can be employed as a bargaining tool to charge exorbitant fees to companies that seek to buy licenses to practice the patent. When the patented invention is but a small component of the product the companies seek to produce and the threat of an injunction is employed simply for undue leverage in negotiations, legal damages may well be sufficient to

¹²⁵ *Rambus Inc. v. F.T.C.* 522 F.3d 456 C.A.D.C., 2008, 461-462.

¹²⁶ *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1337.

¹²⁷ *Ibid.*

¹²⁸ *Case C-27/76, United Brands v. Commission of the European Communities*, [1978] ECR 207, 249-250; *Case COMP/A 36.568/D3 – Scandlines Sverige AB v. Port of Helsingborg*, Decision of 23 July 2004., 214; *Lucent Technologies, Inc. v. Gateway, Inc.* 580 F.3d 1301 (Fed. Cir. 2009), 1337.

¹²⁹ *eBay Inc v. MercExchange, L.L.C.*, 126 S. Ct. 1837 (2006), 1840.

compensate for the infringement and an injunction may not serve the public interest.”¹³⁰

In recent German *Orange book* case, German Supreme Court examined to what extent FRAND commitments can remove injunction relief.¹³¹ In this case, the patent owners sued the defendants for infringement of a patent that was essential to “orange book” standard for CD, which all manufacturers of CD must comply with. The defendants argued that the patent owner abused its dominant position by refusal to conclude a patent licensing agreement with them on FRAND terms and conditions and was therefore not entitled to injunctive relief. The German Supreme Court stated that the standard implementers can defend themselves against a claim for injunctive relief asserted by the patent owner by pleading abuse of a dominant position in the market, and if the patent owner refused to conclude a patent licensing agreement with the defendant on FRAND terms and conditions. However, in order to apply the competition defense successfully, two prerequisites must be fulfilled. Firstly, the defendants must have made an unconditional and binding offer to the patent owners to conclude a patent licensing agreement, which could not have been rejected by the patent owner without violating the prohibition of discrimination or engaging in anticompetitive behavior; secondly, if the defendant has already be using a patent before the conclusion of a licensing agreement, it must anticipate its obligations under such a to be concluded licensing agreement by in particular paying or at least secure the payment of adequate royalties in a trustee account. In this case, the Court found that the above two conditions were not fulfilled, and the injunction relief was granted. The German Supreme Court decision implies that for standard implementers to benefit from the restraints that FRAND imposes on essential patent owners, they must similarly comply with their FRAND obligations of the licensees.¹³² However, it is still questionable, in the specific telecommunication standard circumstance. For example, there are thousands of patents declared as essential to the 3G UMTS standard, it is hard for the standard implementers to fulfill the conditions in the *Orange book* case. This complex situation demands an intermediary between standard implementers and essential patent owners to handle FRAND licensing issues. Only if standard implementers refuse to pay reasonable royalties, can injunction relief be granted.

Another problem concerning FRAND licensing arises from non-disclosure agreement. Goldstein and Kearsy define “non-discriminatory” as that in which neither side suffers in comparison to similar deals struck by either of the parties with outside or other third parties.¹³³ However, a non-disclosure agreement may make such comparison impossible. It is common practice for licensors and licensees to sign a non-disclosure agreement that keeps licensee fees and other conditions secret. In such a case, it is difficult to judge whether license terms are discriminatory because it is impossible to compare the conditions offered to the different licensees. To address this problem, FRAND licenses should be discussed in a public venue rather than hidden behind non-disclosure agreement. However, according to SSO IPR policies, SSOs should not be involved in such licensing issues.

¹³⁰ Ibid., 1842.

¹³¹ Pat Treacy and Helen Hopson, “Rules of the Orange Book,” *Patent World*, 12, 2009, 12-13. Case KZR 39/06 of 6 May 2009

¹³² Ibid., 13.

¹³³ Goldstein and Kearsy, *Technology patent licensing*, 27.

V. Conclusion

SSO IPR policies require SSO members to early disclose their essential IPRs and request these essential IPR holders to make FRAND licensing commitments, otherwise such IPRs may be excluded from a pending standard therefore not considered as essential anymore. By this approach, IPR policies seek to address patent hold-up and patent ambush problems, therefore ease the tensions between IPRs and standards. The legal practices in the EU and the U.S. show that there are clear rules to define FRAND licensing conditions. FRAND commitments may draw a balance between technology owners and standard implementers. On the one hand, it allows technology owner to get a fair return on their R&D investments in exchange for making their IPR available for implementation and implementers; on the other hand, standard implementers can get access to industry standards without worrying about to get injunction and pay excessive royalties, therefore avoid patent hold-up and patent ambush. However, some cases clearly show that the early disclosure rules in current SSO IPR policies may not function properly; as a result, it may render SSO members to circumvent the FRAND commitments, thereby posing a risk of patent ambush. Hence, it is necessary for SSOs to make an improvement on the early disclosure rules. Negative disclosure may fix these flaws that current disclosure rules have.

To resolve the tensions between standards and IPRs would rely on combination of multiple approaches rather than only SSO IPR policy. Yet, undoubtedly a competent IPR policy can promote and facilitate other solutions.